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New York Meeting of the American Electrochemical Society

The splendid success attained at the New York meeting of the American Electrochemical Society last month—as big a success as that of the delightful Philadelphia meeting in the spring—was due to careful planning and arranging a long time in advance. This double success should definitely settle any doubts which may still have been entertained (mostly by outsiders) whether the society is strong enough to stand on its own feet, and perhaps also the other doubt, which has occasionally found expression, whether two meetings a year is not one too many. It is a great pity that it is an impossibility to give an adequate account of the success of the meeting in its social features, in promoting professional solidarity by social intercourse of the members at the various social functions—on the highly enjoyed visit paid to Mr. Edison, to the man and his work, on the exceedingly interesting excursion to the De Lamar copper refinery, and at the charming banquet in Liederkranz Hall. While this success would have been impossible without the good feeling and the esprit de corps which have always been characteristic of the society, yet it is but fair to state that although the whole New York section was interested in planning, arranging, advertising and carrying out, yet by far most of the work was done by, and great credit is due to, Mr. Alois von Isakovics, the secretary of the section. The Chemists' Club and Columbia University were the gracious hosts of the society at the meetings, while the Chemists' Club also entertained the society at one of its enjoyable Smokers. Truly, the Chemists' Club of New York is rapidly becoming the recognized common social home of all the chemists and chemical engineers of this country.

* * *

In an equally effective way an excellent program of papers and lectures had been arranged for the professional sessions, and for this arrangement the thanks of the society are due to its president and secretary, Professors C. F. Burgess and J. W. Richards, and to the efficient Committee on Papers. A full account of the papers presented will be found in this issue. There was so much of interest and value that to go into details would be ungraceful towards those which could not be mentioned here on account of lack of space. But we must notice at least the three very able papers of Dr. Henry Noel Potter, giving the first, yet full, account of the foundation of a new electrochemical industry, that of silicon monoxide. The whole American electrochemical fraternity may be proud of Dr. Potter's work, not solely of the surprising industrial results, but of the scientific researches which form the foundation. Where there is so much to praise a critical remark cannot be suppressed, especially as the criticism we must make is an old one. The program of papers was far too full to permit adequate discussion. We do not see any other possible remedy but to have all papers printed in advance, and then let the society adopt such a rule as now ex-

ists at the meetings of the Iron and Steel Institute, that the meeting shall be devoted solely to discussion, the author of a paper opening the discussion and being limited to ten minutes.

Practical Applications of Colloids.

The colloidal state has been a subject of extended researches in recent years, but has mostly attracted the attention of scientists. The general engineering public has considered the matter as barren of practical results, although this idea is entirely wrong. The colloidal state now begins to make itself felt in a great many different fields. Dr. Whitney, in a lecture before the American Electrochemical Society two years ago, showed an instructive application to the dyeing of textile fabrics. Ferric chloride and potassium ferro-cyanide solutions produce Prussian blue on mixing, and this is a colloid whose precipitation may be prevented by removal of the electrolytes which are formed by the reaction, if the solution is not too strong. This removal may be easily brought about by dialysis. This colloidal Prussian blue will not dye or color a mass of agar jelly suspended in it, nor will it dye cotton—because, as a colloid, it exerts no osmotic pressure and therefore has no tendency to diffuse. It has no tendency to penetrate the jelly or the cotton. But just for the same reason, if in any way the colloid is produced within the jelly or the cotton, it will be impossible to wash it out. Dr. Whitney demonstrated this in the case of jelly by a sample which was treated first with ferric chloride, and after rinsing with potassium ferro cyanide solution. The resulting colloidal dye cannot be washed out from the jelly. This exceedingly pretty experiment shows clearly possibilities in unexpected directions. Last year colloids were much spoken of in connection with an entirely different subject, playing an important part in the publications of Dr. Kuzel on his electric tungsten lamp. While other tungsten filaments are made by the "paste" process and by precipitation on carbon cores, Dr. Kuzel claims to make use of tungsten in the colloidal state. How far this is the case in the industrial manufacture of his lamp is not known.

* * *

Mr. Edward G. Acheson's very interesting lecture on "deflocculated graphite," which will be found elsewhere in this issue, deals with an application of the colloidal state to lubrication, and apparently an exceedingly useful and promising application. The peculiar method of bringing the graphite into the colloidal or "deflocculated" condition should deserve further attention. It would appear to involve a new principle. Though the rationale of the method of forming the colloid is not clear, the invention is a fact, and everybody will congratulate Mr. Acheson upon the success of his never-tiring efforts to carry the triumphs of electrochemistry into new fields. While in this case the production of the colloidal state is the interesting feature, we are reminded of the reverse reaction—the precipitation of a colloid by addition of an opposite colloid or of an electrolyte—in reading Prof. Lorenz' paper on electrolysis of fused salts, an abstract of which will be found in the Synopsis in our present issue. Experimenters have long known that certain additions to the fused bath are useful in increasing the ampere-hour efficiency of operation. Prof. Lorenz shows that their effect is essentially to precipitate any mist or "schliere" which tends to pass from the molten cathode into the bath, with the result that when this mist reaches the anode the useful work of electrolysis is being undone. The metallic mist behaves just as though it was a colloid, and its precipitation takes place apparently just like the precipitation of a colloid. However, this matter also deserves further investigation.

* * *

To pass over again to an entirely different field, it has long been known that a purely chemical theory of the setting of cement must be necessarily unsatisfactory, since it cannot cover all phenomena which are involved. The setting of cement should be regarded rather from the standpoint of physical chemistry. It has also been known that colloids play an important part in the setting of cement. In this respect a contribution by Mr. R. H. Gaines to the discussion of a recent paper by Mr. Wm. B. Fuller, on the laws of proportioning concrete, before the American Society of Civil Engineers, is quite suggestive. Mr. Gaines is chemist of the New York Board of Water Supply, and this Board is carrying on an extended research on the waterproofing of cement. If we leave out all hypothetical refinements of Mr. Gaines' elaborate theory, his argument is simply that since colloids play an important part in the setting of cement, and since the addition of an electrolyte has a decisive effect on colloidal precipitation, it would be worth while to make experiments in which different quantities of a suitable electrolyte are added to the water in the cement. These experiments have been made by Mr. Gaines. The electrolyte chosen was ordinary alum, dilute solutions of which were used to replace the mixing water. The very interesting result is, that by replacing the mixing water with a 1 per cent solution of alum, watertight concrete is obtained of increased mechanical strength, as shown by compression and tensile strength tests. All these different examples show conclusively that the study of colloids is a subject of greatest importance even for the "purely practical man."

The New Levels in the Price of Metals.

If anything is under mechanical strain, there is sure to be fluctuations when the strain is great enough to effect a movement. The first displacement is quick and sudden, and then there are a series of smaller displacements, depending on the relation between the elasticity, inertia and friction of the system. This is true of the recent course of the metal market as it is of any oscillatory motion. The prices of all metals have broken badly in past three months, and are now exhibiting a series of movements, slight, indeed, but still caused by the waves of sentiment. The phenomena can be compared to a heavily dampened pendulum which makes one movement to a new point of equilibrium and then moves slowly back and forth to that point. Copper, as we all know, was placed at 25 cents last winter by conditions of unprecedented demand and a production restricted by lack of labor and railroad facilities, all these natural conditions being intensified by an artificial market manipulation. It has now sunk to below its own natural level of 15 cents, and although it possibly may stay as low as 12 cents, yet we believe that in the winter it will

return to at least 15 cents, even should its price stay for some time below that figure. Indeed, to the careful observer, the metal markets have made a turn for the better in the last part of October. Consumption is still going on, for this is a great big country and is consuming all the while actually, though change in position of floating stocks between producer, refiner, middleman, brass and copper manufacturer, wholesaler, retailer and actual consumer is always shifting, like a sand hill on the desert, by the winds of trade. And Europe is now buying copper in quantities quite the reverse of its course in May.

* * *

Two reasons for this improvement are the fact that business men have decided that hostile legislation will be checked by public opinion, and no extravagance will be allowed, and, secondly, that we have produced large crops of all agricultural staples above the average in amounts and in values equal to the record crop of 1906. This will give us a large credit balance in our favor against Europe. We, therefore, see a tight money market caused by the financing of these crops—strange with our American brains we allow a creation of wealth to restrict trade by a rigid currency system—and the further indication that next March we shall have easy monetary conditions. There are several rocks ahead of us in the metal business. The greatest of these is the high price and inefficiency of labor. Managers would not be perplexed at increased wages were it not for the arrogance of labor when it has gained its point and the fact that when paid more they work less. This is increasing the cost of production of all metals, and certainly this question must be met, seen and conquered by the peculiar genius of the American people for solving new problems in new ways. But this is looking ahead too far, as we are neither prophets nor sons of prophets. For the immediate future, sentiment is adjusting itself to facts, and the healthy recession in business which we hear preached is arrived. But the panicky feeling exhibited in runs on banks and trust companies is foolish. General industry is in good shape throughout this country.

Manual Training Again.

We have always endeavored to bring out in these columns the thesis that the endeavor of the modern industrial world should be to increase the "efficiency of production." It is quite plain that there has been in the past much accomplished in the ways and means of putting capital to good use, and that new natural resources have been created, as it were, by the methods of applied science. The engineer also has had his special training in the modern technical school. But the fourth factor, labor, has, we believe, not had its share of attention. Of course, it is perfectly true that much has been done to improve and ameliorate the condition of the workman, and that his "wage" return is far greater than it was one hundred years ago, but public opinion has been little turned to the question of increasing his efficiency, simply viewing him as a part of the industrial machine. We are particular not to say that his efficiency has not been bettered, for it is manifest that the good clothes, house, food now afforded him have accomplished this to some extent. But we do say that this has been accomplished by no set scheme of those directing affairs of the industrial world but only by more or less haphazard means.

* * *

Leaving aside all question of the good to the state that would arise from a well laid out plan by the leaders of thought, but basing our presentment entirely on the criterion of dollars and cents, it cannot be denied that nothing will increase our nation's wealth so much as to teach the workman how to make a living and also to teach the workman to know how to live. We cannot see what profit it is always to put in high-priced machinery, when it is possible by increasing the number of skilled workmen to do equally as good work with cheaper machinery. There should be a balance between cost of installation and wage. It would seem that our American endeavor has been to exaggerate the importance of the complex and wonderful machine and to neglecct the more complex and more wonderful machine—the human being.

* * *

One of the easiest ways to improve the efficiency of labor is to establish in each State a State's system of manual training with loose national supervision, on the pattern of the Agricultural Department. In these schools correct methods of handicraft would be taught. There are a great many boys who have not the capacity for abstract thinking, but nevertheless have plenty of common sense about concrete things. For these, who are to become the foreman and skilled artisans in the industrial armies, nothing could be better than training in a trades' school. This is especially true of the mineral industry. The essential facts about the action of a Wilfley table, for instance, could be explained in such a school. We do not need to go into further details, for the real want of such a system of schools is too apparent. The State of Wisconsin, which seems to be about as far advanced in educational matters as any State, has undertaken to found such a school for the mineral industry, where earnest effort will have a chance. We doubt not that such an enlightened course will have good results. Indeed, it would not be unexpected if some of the big men of the future would be evolved from just such schools. It seems a suitable soil. But these schools should also do more; they should teach the art of right living as well as the trade of earning a living. A broad humanistic spirit present if these would have a wonderful influence for better things in the army of toil. The oddities and crudities of many a workman come from the fact that his being is dwarfed by his environment. Give him half a chance to grow along right lines and the result will be surprising. Especially to be commended in this connection is the attempt of Postmaster-General Meyer to found a postal savings bank throughout our country. This will give the workman a chance to keep his savings under the guarantee of the national government. The annual increment to our savings from this source might be enough to build the Panama Canal. There would be considerably fewer gamblers, prostitutes and barkeepers in the Western mining camps, but a great many more contented workmen. Viewing the whole subject of advance in the industrial efficiency of the workman "en perspectif," we believe that a system of manual training schools and postal savings banks, coupled with a few more good ideas from those aristocrats of our democracy, the leaders of public thought will increase the wealth both material and moral of the country and, by inductive example, of the world.

The Iron and Steel Market.

October has brought forth definite developments. The first important downward trend of the curves of prices and productions has been made, and the movement has been quite in line with what has naturally been in view for months. As long ago as last March this review said: "It is clear that the crest has been passed in the iron and steel trade. * * * The indications thus are that while the greatest activity should prevail for six or nine months to come, there will be some recession in demand late this year, and in 1908."

This prediction has been verified even more closely than could have been hoped for. The pressure for deliveries upon the large mass of business which then stood upon order books was maintained in a remarkable way through a period of many months of quite niggardly new buying, and steel mills were justified in their claims of early in the year that the orders they had booked were of the soundest description.

This business has played out, and with it has come a slowing down in production. It has come earlier at some points than at others. Tin plate was affected first, the leading interest by the middle of October having barely 30 per cent. of its tin mills in operation. Sheets came next, with a few mills closed. The iron mills, both in the East and in the Central West, operated in October to but a half or two-thirds their maximum capacity. Rail output is to be decreased, but this is partly a matter of season. The No. 2 rail mill at Edgar Thomson will close shortly, to be followed by the other two rail mills in that plant.

The Carnegie Steel Co. is closing steel mills in rotation, according to their economy. Bellaire was closed Oct. 22, and Columbus is following. These plants may remain idle for a long time. Homestead is being closed for a relatively brief period, for repairs.

Pig iron production usually increases month by month after the high humidity of July and August, and September showed an increase over August, the low point of the year, barring March, but instead of the curve trending sharply upward, as it did in the past three years, there is certain to be a sharp drop, much as that which occurred in the latter part of 1903, when the decline was from an annual rate of 17,200,000 tons in October, to a rate of 10,500,000 tons in December. The rate in September of this year was 27,000,000 tons. It requires the courage of much careful consideration to predict a decline in the rate to less than 20,000,000 tons by the end of this year, yet such a prediction seems to be quite in order.

The iron and steel trade has naturally been disturbed by the embarrassments in financial circles and by the involvement of certain of the Westinghouse interests, but as a matter of fact little of the change in the iron and steel situation has been due to these influences. The change was bound to come in any event, due rather to the general pathological condition than to the influence of eruptions at specific points. The iron and steel trade is much freer than it has ever been before from adverse influences due to the impairment of credit. Sales are made on a more strictly cash basis than ever before, and through the consolidations a large part of the production has been taken from the hands of individual interests, which would naturally be large borrowers and put in the hands of strong companies the nature of which brought them to amass large surpluses in cash and quick assets. It is not impossible that these large interests should become financially embarrassed at some time, but this can come only through impairment of their cash resources through a long period of depressed demand, and cannot come directly through the impairment of credit.

Pig Iron.

The pig iron market has become involved through the utter disinclination of consumers to enter upon engagements for 1908. Two or three months ago there was a little buying for 1908 deliveries, at prices lower than were asked for this year's delivery, and it appeared that the market might slide off from its undue elevation without passing over any precipices, but as the time approached there came a positive refusal to discuss next year's business and furnaces have been thrown into the position of making the most they can of this year, without regard to next. Bessemer pig iron has been stubbornly held at $22, valley furnace, when this price has been obviously out of line. Foundry and basic pig have declined, but are still quite out of a line which could merge with what must be done for next year. Basic pig has been sold at $19, valley. Southern pig iron has broken and may reach a basis sooner than Northern iron. It is freely offered on the basis of $17, Birmingham, for this year, against $18 a month ago.

The merchant furnaces are quite indifferent to the situation since there has been little prospect of their selling enough iron fully to engage their capacity, and they prefer to have their hands free to blow out when present contracts are completed. This blowing out process has just begun, but will have become pronounced by the end of November.

Steel.

Substantially all the Bessemer steel works are offering billets in the open market, whereas a month ago the majority were reported as being sold up for the remainder of the year. Bessemer billets have been freely offered at $28, delivered Pittsburg, and can be bought at $26 to $27, f. o. b. some producers' mills. There appears to be a stampede among open-hearth mills, and open-hearth billets are offered at little above Bessemer, with the interesting possibility that open-hearth billets may become cheaper than Bessemer.

Finished Material.

Black sheets have been generally shaded $2 a ton, while it is regarded as only a matter of mills catching up in deliveries for galvanized sheets to follow suit. There are rumors that steel bars are being shaded $2 a ton by important interests. Light rails have been reduced $3 a ton. Plates and shapes, and of course standard rails, are firm. Iron bars are extremely irregular, and cannot be quoted.

New demand is extremely light all along the line, except that there is a good movement in wire products. Producers are working on the tail end of old orders, which are holding out better in plates, shapes and steel bars than in other lines.

Regular mill prices are unchanged and we quote them as follows, it being noted that black sheets at least are being shaded, these prices being f. o. b. Pittsburg, per 100 pounds:

Structural shapes, $1.70 for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60, base.

Sheets, 28 gauge, $2.60 for black, and $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Application of the Laws of Physical Chemistry in the Metallurgy of Iron.*

By Baron H. von Jüptner.

There is at the present time an almost daily increase in the cases in which industrial practice is profiting by the application of the laws of modern physical chemistry. Whilst in earlier publications on the application of physical chemistry to the metallurgy of iron the doctrine of the phase rule in its application to iron alloys and slags was chiefly dwelt on, the author will in the present case deal with the doctrine of chemical equilibrium as applied to metallurgical chemical processes.

But before we enter upon this it may be well to explain

*A paper read at the Vienna meeting of the Iron and Steel Institute, September, 1907. Slightly abstracted. Abstracts of all other papers presented at that meeting were given in our October issue.

the subject shortly, and in such a manner that on the one hand a clear mechanical view of the working capacity of chemical reactions, and on the other hand a true scientific treatment of the inner working of the problems may be obtained.

I.

All chemical processes are conditional upon the affinity of the reacting bodies. If the value of these affinities (which vary, however, with the physical conditions of temperature, pressure, etc.) are known, it may be foretold in every individual case, from mathematical reasoning, what chemical alterations will take place in any given reacting mixture.

In order to obtain a thoroughly comprehensive idea of the chemical affinities we can best start with the phenomena attending evaporation.

If we partially fill an empty closed vessel with a liquid and evaporate this until a certain vapor pressure is reached, the degree of this will be solely connected with the temperature employed.

If now we attempt to increase the vapor pressure above the liquid, either by decreasing the space the vapor can occupy by pressing down the piston or by pumping in vapor from the exterior, we shall not succeed. We shall only effect the condensation of a part of the vapor, so that the vapor pressure p, which bears on the fluid, remains constant.

The reverse of this experiment, that is, the attempt to diminish the vapor pressure above the liquid, either by raising the piston or by exhausting vapor out of the vessel, also does not lead to the desired result. We only succeed in evaporating more of the fluid, so that the vapor pressure still remains unaltered.

The two examples described show us, therefore, what we actually do is either to pump vapor into the liquid or out of it. The work which we have to do in order to condense in this manner a certain quantity, for example, 1 gram-molecule of vapor, or, what is the same thing, the work, which the fluid performs when a certain quantity of it is evaporated, and which we will call the molecular evaporation energy, can be readily calculated. As the measure of the same, the maximum pressure of vapor (the vapor tension), or what is not only more exact, but also, as we shall soon see, more convenient and suitable, the logarithm of this pressure, may be employed.

Quite similar phenomena to those of evaporation take place on the dissociation of such solid or liquid bodies that develop a gaseous constituent. Thus, for example, if we heat calcic carbonate in a closed vessel to a sufficiently high temperature, a part of it decomposes into CaO and CO_2. This goes on until the partial pressure of the CO_2 set free reaches a certain value dependent on the temperature (we will denote this pressure by $[CO_2]$). If we keep the temperature constant, we can by pumping in CO_2 or by pressing down the piston, bring about the reformation of $CaCO_3$. On the other hand, we can by pumping out CO_2 from the vessel bring about a further decomposition of the $CaCO_3$.

Thus we can here also, exactly in the same way as with the vapor, pump the CO_2 *out of* or *into* the $CaCO_3$. The energy which we must employ in order to extract one molecule of CO_2 from $CaCO_3$, or to combine it with the CaCO, that is the work necessary in order to form or to decompose one molecule of $CaCO_3$, can be calculated just as in the former case, and the maximum pressure of CO_2 which is observed (and which is designated the tension of dissociation), can be considered as the mass of the work.

In air saturated with moisture no water can evaporate. In a similar manner $CaCO_3$ cannot be dissociated in CO_2 above its dissociation pressure. If at the commencement there should not be so much water vapor or CO_2 in the space occupied by the gas as corresponds to the maximum tension then water vapor will evaporate or CO_2 will be developed until such a maximum pressure is reached.

If a body on dissociation gives out two or more different gases there is a special dissociation pressure for each of them, at which the decomposition ends. Solid NH_4Cl decomposes on evaporation almost entirely into NH_3 and HCl. This decomposition will obviously stop when the partial pressure of these two bodies $[NH_3]$ and $[HCl]$ has attained a certain maximum value. Now, since by the decomposition of the NH_4Cl equal quantities of NH_3 and HCl are formed, the partial pressure of both must be equal, that is to say,

$$[NH_3] = [HCl];$$

and the total pressure which is necessary in order to prevent the decomposition of the NH_4Cl must obviously be

$$P = [NH_3] + [HCl] = 2[NH_3] = [HCl].$$

If, however, there should be in the space in which we want to volatilize the sal-ammoniac, evidence of the two decomposition products already present a smaller quantity of ammonium chloride will be evaporated than if this were not the case, and it might be thought that the volatilization could be prevented if the partial pressure of the NH_3 thus originally present were as great as the maximum NH_3 pressure, which could be produced by the decomposition of the sal-ammoniac. This, however, is not correct. Even if the partial pressure of the ammonia originally present be far greater, there is always a certain quantity of the sal-ammoniac volatilized or decomposed. Here is the law for a given temperature:

$$\log [NH_3] + \log [HCl] = K.$$

But these proportions become rather more complicated if the decomposition products produced at this temperature are present in unequal molecular quantities as by the decomposition of HgO,

$$2HgO = 2Hg + O_2.$$

Since our amount of work applies to every single gas molecule produced, we clearly have

$$2 \log [Hg] + \log [O_2] = K.$$

We may look upon the above-mentioned dissociations as a kind of volatilization, and so arrive at the following general scheme for the phenomena of volatilization:

1. The body volatilizations as a whole, without recomposition (volatilization in the restricted sense).

2. The body volatilizes as a whole, but in so doing is decomposed solely into gaseous decomposition products (for example, $HgO.NH_4Cl$, etc.).

3. The body only partially volatilizes; it is thereby decomposed, and besides gaseous decomposition products, forms a solid or liquid residue (for example, $CaCO_3$).

4. The body furnishes gaseous decomposition products, but is at the same time also volatilized undecomposed.

All that has been said above applies also to the solution of solid bodies; only then in place of vapor tension or the tension of dissociation, the tension of solution and the osmotic pressure must be considered.

We can, therefore, assume for every compound solid body a tension of dissociation dependent solely on the temperature, and if this is known for any materials, we can therefrom determine their mutual influence. Of course, we must know the law according to which the tension of dissociation alters with the temperature, but we will here confine ourselves to saying that the first increases with increasing temperature.

If we heat a mixture of BaO_2 and BaO in air to a moderate temperature, the tension of dissociation, or, in other words, its oxygen pressure, is lessened, and in fact is smaller than the oxygen pressure in the atmosphere (0.21 atmosphere). Due to its excess of pressure the atmospheric oxygen will be absorbed by the BaO, that is, it will oxidize this latter into BaO_2. If we increase the temperature further, the tension of dissociation of the BaO_2 is increased gradually and finally becomes greater than the oxygen pressure of the atmosphere, and then BaO cannot be further oxidized into BaO_2, but on the contrary this latter will be decomposed. Upon this the

well-known process of Boussignault for obtaining oxygen from the atmosphere is founded.

There is also a certain sulphur tension for lead sulphide and for iron sulphide for every temperature, and indeed in the smelting of lead the temperature employed for the reduction of FeS is smaller than that for PbS. Sulphide of iron, therefore, does not act upon lead, whilst iron decomposes molten lead sulphide. There is, therefore, formed sulphide of iron and lead $PbS + Fe = FeS + Pb$; and upon this the so-called "precipitation" process depends. These few examples may suffice to show the importance which the knowledge of the dissociation processes possesses.

(To be Concluded.)

Cost of Water Power.

The following data on the cost of developing the water power which supplies the electrolytic plant at Vallorbe, in Switzerland, with current will be found of interest. They are taken from a recent issue of the London *Electrical Review*. The height of fall is 70 m., the power utilized amounts to 3,000 hp., and the output of the works is 900 to 1,000 tons of chlorates per year, calculated at the round figure of 1 ton per horse-power day. The expenditure was allocated as follows:

Concession and land	$6,000
Dam	4,000
Tunnel, etc.	10,000
Pipe line	6,000
Turbines and sluice-gates	22,000
Buildings	4,000
Dynamos	60,000
Sundries	8,000
	$120,000

Thus the cost per horse-power was $40. Interest and depreciation at 10 per cent make $4 per horse-power per annum. These results are exceptionally favorable; more usually, it is stated, the cost of installation would average $80 per horse-power, and the annual charges $8.

CORRESPONDENCE

A Metallurgical Revival.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—One of the most extraordinary things of the present time is the revival of old methods as new to the rising generation.

The "Lash process," as described in your issues of August and September, was used at Landore, South Wales, nearly thirty years ago, and was then called the "Batch method." The late Sir William Siemens was very "sweet" upon it. We used "purple ore" from the sulphuric acid works, which we could get very cheap, and other ores mixed with cast iron borings and turnings from Woolwich Arsenal and other works, and we also had some black sand from New Zealand.

It worked well and made good steel in the open-hearth furnace, but died from lack of cast iron borings in sufficient quantity. We added carbon, such as coke and coal dust and ordinary fluxes. I still have my notebooks on these "Batch" charges, but they are stored away in Pittsburg, Pa.

It is a very good method and works well, and I have often wondered why it was not revived. I think some account of these "Batch" charges may be found in old numbers of the *London Institute of Civil Engineers, Journal* of Iron and Steel Institute, and *Journal* of the (London) Chemical Society and Society of Arts. I know Sir William described it in some of his lectures.

On page 360 of your September issue is an article by Dr. O. Nagel on the "Use of Producer Gas, Etc." The drawings shown are almost exactly like some made in Sir William Siemens' office thirty years ago.

Sir William Siemens was a great inventor and experimenter, and I often think of a remark he made to me after we had melted steel in the first electric furnace with a gas producer and gas engine for power. He said: "It will take a quarter of a century for these experiments of mine to come into practical use; you may live to see it, but I shall not." I see the truth of his remark now. Walter E. Koch.

(For ten years engineer with the late Sir William Siemens.)

El Paso, Tex.

Gas Analysis.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—On pages 350 to 352 of the September issue of your journal, Mr. Edwin Barnhart describes a very practical apparatus for gas analysis, which appears to be complete except that no provision is made to prevent the burette stopper from jumping out should any pressure occur in the burette.

I should like to enumerate some of my (and also others') experience regarding the absorption of the last traces of carbon monoxide. I have found it most accurate to pass the gas from the ammoniacal cuprous chloride solution, where most of the carbon monoxide has been absorbed, to another pipette containing a very slightly used ammoniacal cuprous chloride solution, where the last traces of carbon monoxide are quickly and entirely absorbed. The disadvantage of using an acid solution of cuprous chloride, as Mr. Barnhart describes, is that the absorption of carbon monoxide is never quantitative, as the compound dicarbonyl cuprous chloride (Cu_2Cl_2, $2CO + 4H_2O$) formed is of a very unstable nature in acid solution, and it requires a certain counter pressure of carbon monoxide to prevent it decomposing, as follows:

$$Cu_2Cl_2,\ 2CO = Cu_2Cl_2 + 2CO.$$

This reaction is reversible, and when an excess of carbon monoxide is present reacts from right to left, but when an acid solution of this compound is shaken with a gas rest containing no carbon monoxide the above reaction takes place from left to right and carbon monoxide can be detected in the gas rest.

For exploding the gas rest I have found it quickest and most convenient to use very slightly acidulated water instead of mercury, which is rather cumbersome for very rapid work, and I also use this water in my burette so that the ammonia is readily absorbed, and after the explosion the water does not absorb any of the carbon dioxide formed.

Perth Amboy, N. J. Herbert Philipp.

Carbons for Electrometallurgy

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I have just received Vol. XI. of the *Transactions* of the American Electrochemical Society. On page 324 there is printed the discussion following the paper presented by FitzGerald and Forssell, and any one who takes the trouble to read this will certainly be puzzled.

The discussion as printed opens with a communication from FitzGerald and Forssell, which gives the result of an investigation of a certain phenomenon unexplained in the paper and the subject of the discussion which followed. As the communication from FitzGerald and Forssell finally settled the matter that was under discussion, it should be read as a communicated discussion *after* the discussion which really took place at the meeting.

Francis A. J. FitzGerald.

Niagara Falls, N. Y.

NEW YORK MEETING AMERICAN ELECTROCHEMICAL SOCIETY.

The twelfth general meeting of the American Electrochemical Society was held in New York City on Thursday. Friday and Saturday, Oct. 17, 18 and 19.

On the evening of Oct. 17 a reception was held at the Chemists' Club, and after the President, Prof. C. F. Burgess, had called the meeting to order, two lectures of general interest, illustrated by lantern slides and demonstrations, were presented. Dr. Geo. F. Kunz, the well-known gem expert of Tiffany & Co., spoke on diamonds and moissanite, natural, artificial and meteoric, while Mr. E. G. Acheson, whom Dr. Chandler called the "Wizard of Niagara Falls," spoke on deflocculated graphite. Abstracts of these lectures are given below.

The morning session of Oct. 17, held at the Chemists' Club, and the morning session of Oct. 19, held at Columbia University, were devoted to the reading and discussion of papers. Full accounts of the papers presented will be found below.

In the afternoon of Friday an excursion was made to Llwellyn Park, Orange, N. J., to visit the laboratories of Mr. Thomas Alva Edison. Mr. and Mrs. Edison received the party in the library in a very cordial manner, and the visitors were conducted in small parties through selected portions of the laboratories and the phonograph works. It appears that the celebrated nickel-iron storage battery, to which Mr. Edison has devoted the last ten years in hard and continuous work, is about to re-enter the market after several improvements have been successfully made. Considerable attention was paid to the model of an all-concrete $1,000-house for workingmen, a wholesale manufacture of which is Mr. Edison's latest scheme. The New York dailies of the next morning devoted considerable space to the project.

On the evening of Friday a dinner was held in the beautiful banquet hall of the German Liederkranz Society. It was very well attended and was a delightful affair. Prof. C. F. Chandler was, as ever, a magnificent toast-master, toasts being responded to by Prof. C. F. Burgess, Prof. S. A. Tucker, Dr. J. W. Richards, Mr. E. G. Acheson, Dr. W. R. Whitney, Dr. Henry Noel Potter, Dr. Charles Baskerville, Mr. J. Hasslacher, Mr. Draeger and Prof. M. T. Bogert. Vocal selections, presented by the young Liederkranz Quartette, Messrs. Theo. Trautmann, Edw. L. Seip, N. C. Latterner and Jos. M. Kahn, were greatly enjoyed.

PHOTOGRAPH TAKEN AT THE BANQUET IN LIEDERKRANZ HALL.

For the afternoon of Saturday two excursions had been arranged: one to the new power plant of the Pennsylvania Railroad at Long Island City and the Electrical Testing Laboratories in New York; the other to the magnificent and recently greatly enlarged plant of the United States Metals Refining Co. (De Lamar refinery) in Chrome, N. J., where the process of copper smelting, converting and electrolytic copper refining and the electrolytic parting of dore bullion were shown in operation.

The meeting was concluded by a very enjoyable smoker, tendered to the Society by the Chemists' Club at its club house on Saturday night.

In the following we give abstracts of the papers which were presented at the meeting. No attempt is made to give them in the order in which they were read, but rather to group those together which deal with kindred subjects.

Silicon Monoxide.

Three exceedingly interesting and valuable papers on silicon monoxide were presented by Dr. Henry Noel Potter. Of these the first, presented in the Friday session, discussed the scientific questions involved in the problem, while the two other papers which were presented in the Saturday session dealt respectively with the properties of the brown powder "monox" (silicon monoxide) which determine its commercial applications, and with the electric arc furnace for making monox.

In the scientific paper, Dr. Potter points out that theoretically silicon, like carbon, should have a monoxide as well as a dioxide, but in the case of silicon only the dioxide has been recognized. Clemens Winkler attempted to form silicon monoxide, and reports: "It is supposed that SiO does not exist, for even in heating a mixture of SiO_2 and Si, the reaction $SiO_2 + Si = 2SiO$ does not result."

As this experiment was performed in a combustion furnace, under conditions where the maximum temperature probably did not exceed 1,000° C., the conclusions based thereon can only be accepted within the temperature range involved.

If the Winkler experiment be extended to temperatures attainable with ease in the electric furnace, a brisk reaction takes place, with liberation of a brown smoke which burns to silicon dioxide. If the reaction is effected in an inert atmosphere in a furnace of the resistance type, the smoke can be collected as a soft, brown, very fine and voluminous deposit upon all exposed surfaces within the furnace.

Dr. Potter gives details of the analyses of samples of this brown deposit and the calculated amounts of SiO contained in it. Before declaring that in these experiments the reaction

$$Si + SiO_2 = 2SiO$$

has been realized, Dr. Potter discusses in detail two objections. First, it might be thought that the reaction was wholly between the carbon of the resistor of the furnace and the silica of the charge, and that the free silicon itself took no part in it. A second objection might be that perhaps no inter-reaction at all took place, and that both silicon and silica were distilled, side by side, without reacting upon each other.

Both objections are clearly proven to be not valid, and it is conclusively established that silicon can and does reduce its own dioxide (the reaction being quite brisk at temperatures between 1,700° and 1,800° C.) with the production of a lower oxide, which analysis indicates to be the monoxide. As high temperature products are usually characterized by simplicity of composition, the formula may be assumed to be SiO.

If carbon or silicon carbide be used as reducing agent in place of silicon, the brown powder is produced in voluminous quantities. An arc furnace can be substituted for the resistance furnace, and the yield per unit of electrical power employed considerably increased. With increased heat concentration, however, the amount of silica distilled appears to be increased, as the percentage of total silicon in the brown powder decreases.

While the proportion of silica to reducing agent has practically no effect upon the proportion of silicon in the product, it nevertheless has a considerable influence upon the yield.

This was shown in a number of runs using carborundum as reducing agent and varying the composition of the charge. The highest yield was obtained when the charge was made up according to the formula:

$$2SiO_2 + SiC = 3SiO + CO.$$

If the proportion of carborundum or of silica was increased the yield was reduced in either case. With purified carbon as reducing agent, the highest yield was obtained with the theoretically correct mixture according to the equation

$$SiO_2 + C = SiO + CO.$$

In view of the chemical analogy between carbon monoxide and silicon monoxide, it would seem theoretically possible that, even though silicon monoxide does exist as such at electric-furnace temperatures, nevertheless, on cooling, it would dissociate in accordance with the formula:

$$2SiO = SiO_2 + Si.$$

A great deal of chemical investigation was gone through with by Dr. Potter to find if possible some property of the brown powder which should be different from any possible property of a mixture of silicon and silica.

It was thought for a time that such a property had been discovered when it was found that the brown powder, when freshly prepared, dissociates water with the liberation of hydrogen. This reaction takes place slowly with ice water and is brisk with boiling water. The evolution of gas, however, soon ceases, due doubtless to the coating of silica produced upon the particles by the reaction.

It was subsequently found, however, that both crystalline and amorphous silicon have this property of dissociating water, provided the surfaces of the particles have not had opportunity of becoming covered with a protecting film, which they soon acquire on exposure to the atmosphere.

This property of silicon can be quite readily shown by dissolving off the film with hydrofluoric acid, and after washing off the acid in cold water, throwing the new active silicon particles into boiling water. In the case of finely granular silicon, the hydrogen liberated will adhere to the particles and float them up to the surface.

The thickness of this film was determined, and assuming the particles to be cubes 0.001 millimeter on a side, the thickness of the film was calculated to be 0.00000016 millimeter. This is a thickness which is small, even in comparison with a length of a single wave of violet light. The presence of this film doubtless underlies the successful application of silicon crystals as receivers for wireless telegraphy.

No chemical test could be found which would enable one to distinguish silicon monoxide from a mixture of silicon and silica, such as would be produced by the dissociation of silicon monoxide. Dr. Potter, therefore, undertook physical tests.

The first investigation along this line was to measure the heat of combination of the brown powder in a special bomb calorimeter.

The heat of combustion observed must be due either to the combustion of

$$2Si + 2O_2 = 2SiO_2,$$

or

$$2SiO + O_2 = 2SiO_2.$$

In the former case the heat of combustion should be that of amorphous silicon, in the latter it may be different, just as the combustion of two molecules of carbon monoxide yields more heat than the combustion of one atom of carbon.

The end result of the extended and exceedingly careful determinations of Dr. Potter is that, that on the whole, the heat of combustion of the brown powder varies from sample to sample, but that it is consistently higher than can be explained on the basis of the combustion of silicon in any known form.

Dr. Potter's figure for the combustion heat of his crystalline silicon is 7.595 gram calories per gram of silicon burned.

Dr. Potter's brown powder, which is essentially silicon monoxide, is different from Mr. Tone's brown vitreous material formed in the silicon furnace. The latter is a mixture of silicon and silica in theoretical proportions; it was true monoxide at a high temperature, but in cooling off it has completely dissociated.

The difference which has been shown to exist between the brown vitreous material and the brown powder can be plausibly explained as due to the difference in the conditions surrounding their formation.

The furnace in which the brown powder is now made is the latest of a number of experimental devices, all having the same characteristics, namely, an arc between two opposed

horizontal carbon electrodes, in a closed chamber consisting of a body containing the charge and a cover of considerable volume. The theoretically important conditions are that the charge should surround the arc, that the arc should not be buried too deeply beneath the upper surface of the charge, that the hollow space or crater which forms about the arc when it operates shall soon work to the surface of the charge and break through into the empty space above, forming a discharge throat, and finally that this empty space shall be large enough and so shaped that the bounding walls nowhere approach the throat near enough for the highly heated blast of gas therefrom to strike them.

When the furnace has been in operation long enough for the crater to have formed a throat, and the normal process to be in operation, the reaction occurs on the inner walls of the crater. The silicon monoxide is apparently released in the gaseous state, enabling it to rush out of the crater almost instantly, along with the liberated carbon monoxide. Once out of the throat, the gases expand very rapidly and are instantly chilled so that the silicon monoxide does not have time to completely dissociate before it is brought down to a temperature at which its speed of dissociation is practically zero, all of which is in strict analogy with the known dissociation phenomenon of carbon monoxide, the only difference being that silicon monoxide happens to be a solid and not a gas at ordinary temperatures.

It would appear that silicon monoxide is a sublimate, as the author has not been able to liquify it in a tubular resistance furnace at a temperature of 1,700° C. The sample pieces grow smaller, but the edges remain sharp, indicating sublimation without softening.

The brown vitreous material is apparently produced by the cooling gaseous silicon monoxide upon the walls of gas passages through the charge material in the furnace, and owing to its slow cooling, dissociation has ample time to become complete.

These theories have received a curious confirmation by specific heat measurements. In the case of an ordinary substance obeying the law of Dulong and Petit, it would be impossible by a comparison of specific heats to determine whether the substance examined was a mixture or a compound, but silicon does not follow this law, but has a specific heat, which, within ordinary temperature ranges is too low, but which grows higher and higher with increased temperature.

The silicon dioxide follows the abnormal character of silicon in its specific heat, indicating that whatever the cause of the change of the specific heat of a silicon molecule on cooling, it applies to the silicon within the silica molecule.

It has been supposed that compounds consisting of relatively few atoms have a specific heat which is an additive function of the heats of their component atoms, but that where abnormal heat capacity is shown, that this is due to some change in the molecular structure. This is almost the only clue we have to structural changes occurring within the molecule of solid substances.

It seemed possible that in the case of silicon monoxide, which is normally a high-temperature compound and exists at ordinary temperatures only by virtue of an accident of cooling, that the molecular structure must preserve the peculiarities of the normal high temperature condition, and that the specific heat of such a compound should be higher than that of the mixture resulting from dissociation.

This hypothesis was indeed fully confirmed by a very careful research made with a specially designed, very accurate calorimeter of high refinement. It was found that the specific heat of a mixture of silica and silicon in equivalent proportions ("pseudomonoxide") and the specific heat of Mr. Tone's brown vitreous material agree well together, the figures being 0.1828 and 0.1833. On the other hand, Dr. Potter's brown powder has a specific heat above 0.2. When the brown powder was heated at 400° C. for several hours, and when the specific heat was redetermined afterwards, the lower value 0.18 was found, showing that a molecular change had taken place, which can be readily explained as a dissociation.

To the brown material the name "monox" has been given, this name covering the material in the dissociated, as well as in the undissociated condition, inasmuch as there is no industrial distinction between the two, as yet determined.

The chemical properties have already been touched on. In general they are conditioned by the presence of a film of silica over the particles, so that until this film is removed, the properties are those of silica.

The specific gravity of the brown powder, as produced impure, is 2.24, or 2.191 as SiO after correcting from impurities.

The color dry, is a light-yellowish brown, when wet with water or oil, a darker and more neutral brown. The higher the refractive index of the wetting liquid, the darker the brown. Probably the darkest brown and true color would be seen when the powder is wet with a liquid having the same index as the silica film.

The size of the ultimate particles is very small, it being of the same order as those of soot or carbon blacks.

The heat insulating and electrical insulating properties are high. It is remarkably negative when electrostatically charged by friction. This property, however, seems to depend on fineness of particle, or extent of surface.

The brown powder is extremely opaque, both dry and wet, a property that harmonizes with the idea of at least a partial dissociation, and therefore the presence of an electric conductor, namely, silicon.

This research was carried out for Mr. George Westinghouse, to whom Dr. Potter expressed his great indebtedness "for his patience and continued interest during the long period over which the research has extended."

Monox.

The industrial applications of the brown powder "monox" (silicon monoxide) were the subject of the second paper of DR. HENRY NOEL POTTER. Various of the properties of monox have already been covered in the above abstract of his paper on silicon monoxide.

The true density of monox is about 2.24, but it is so voluminous as to weigh, when simply shoveled into a box, only about 2½ pounds per cubic foot. It may thus seem to fill over fifty times the space it really occupies.

Dry monox is powerfully negatively electrostatically charged on the slightest provocation, such, for example, as drawing it suspended in dry air through a short rubber pipe. When so charged it flies and adheres to all non-conducting surfaces, such as a cotton or other fabric, and in this way it can be filtered out of air or other gas in which it is suspended, and accumulates as a layer over the fabric, without caking together or very materially hindering the passage of gas.

Such a screen, coated with adhering monox is impervious to fine solid particles of any sort such as those constituting cigar smoke or the fine particles formed when gaseous ammonia reacts with gaseous hydrochloric acid. Germs and all such organisms are stopped so that air drawn through such a screen is sterile. This is a broad field of application, but has not been thoroughly investigated as yet.

Monox has in a remarkable degree the power of thickening fluids with which it is mixed, and this, together with its chemical inertness, its opacity, and its pleasant light color render it a very valuable pigment in certain oil paints, in particular paints for brick work and paints for protecting structural iron from rusting.

In the following table are given the relations by weight and by volume of various pigments and raw linseed oil, when mixed into paints of good thickness to spread properly:

Monox paint, owing to its extremely high oil ratio can be used with advantage thicker than the painter is accustomed to handle.

PIGMENT RATIOS.

No.	Pigment.	Sp. Gr.	Approximate Per Cent in Paint by Weight.	Approximate Per Cent in Paint by Volume.	Weight per Gallon. Lbs.
1	White lead.....	6.43	80	36.6	21–24
2	Red lead.....	8.53	88+	45.4	30–35
3	Zinc oxide.....	5.60	57+	18.1	14.8
4	Iron oxide.....	....	..	....	15.6
	Indian red.....	4.32	64+	27.5	....
5	Ochre.....	2.97	50	25.7	11.8
6	Monox.....	2.2	20	10.2	8.6

With certain reservations necessary in any general statement concerning such a complicated subject as the weathering of paint, the paint having the highest volumetric ratio of oil should be the most durable, whether on iron or wood or stone. In all these respects monox is excellent and in direct competition with other pigments in practice has shown most gratifying durability.

Another somewhat kindred application of monox is for making inks. The contribution of monox to black printing ink containing it is to make the ink "lay" perfectly and dry with a dead lustreless black, which will not easily offset. In higher grade inks the color is always improved by adding a blue or other "toning" color, and these "toners" help to make the ink lay in some cases, but as their function is to color the ink, the amount introduced must be limited to that giving the desired tone, whether the ink lays or not. There is thus a chance to introduce a third ingredient beside black and toner, whose function is to make the ink lay. This monox does very nearly perfectly.

A further application of monox is in ceramics. All ceramic materials contain silicon and are fired to render them permanent in form or location. Many of the technical difficulties are due to the firing. As monox may burn to silica under proper conditions of mixture with oxides or exposure to oxidizing flame, it may, in certain cases, be substituted for a part or all of the silica with advantage. In burning to silica, monox liberates considerable heat, and thus a sort of suto-firing may occur. This seems to promise certain advantages in glazes and in other departments, but it is at present too early to definitely state.

Other experiments made by Dr. Potter and briefly noticed in the paper referred to the use of monox as a lubricant, as a polishing powder and as a heat insulator.

Electric Furnace for Making Monox.

Dr. HENRY NOEL POTTER's third paper describes the electric furnace in which monox is made. A diagram of the furnace is shown in Fig. 1.

Silicon monoxide is produced when silica, ordinarily in the form of glass-maker's sand, is heated in contact with coke, graphite, silicon carbide, silicon or intermediate reducing agents, such as siloxicon and carborundum fire-sand containing silicon, carbon and oxygen.

Under the usual conditions of electric furnace arrangement and operation, the silicon monoxide cannot escape and is further reduced to silicon or to silicon carbide. It exists under such conditions only transiently, but can be shown by inserting a carbon tube into a furnace which is producing silicon. Through this tube, a brown smoke and gases may be drawn, representing the condensed atmosphere within the furnace. This will be found to contain monoxide in abundance, but little or no free silicon. This appears to be due to the high boiling point of silicon, which lies higher than the sublimation temperature of silicon monoxide, so that on gaseous silicon monoxide being reduced, liquid silicon results, which collects into drops and trickles down the walls and so collects in the pool where it is found.

The liberation of both silicon monoxide and carbon monoxide as gases, causes an elevation of gas pressure at the place of reaction. If the thickness and weight of charge above the region of reaction is not great, and if there is a free space above the charge, the gases will work their way upward and outward with such force as to open a passage through the overlying charge, and through this passage the hot gases will rush, widening it out into a throat and piling up a cone of displaced material about the throat opening like a little volcano.

Under such conditions there can be no great increase of gas pressure in the reaction region, and the gases as soon as they form, burst out through the throat in an incandescent blast.

Thus it happens that the silicon monoxide does not remain long enough in the reaction region to become fully reduced, but escapes almost as soon as formed and is chilled very rapidly.

If such a throat discharges silicon monoxide and carbon monoxide into the air, they burn with great violence and liberation of heat, with production of clouds of fine silica. If, on the contrary, the throat discharges into a large container free from air, preferably under reduced pressure, the products in the blast do not burn, but cool with great rapidity and deposit on the walls and all exposed surfaces within the container the fine brown powder "monox."

The present commercial furnace consists of a cylindrical cast-iron drum about 5 feet in diameter, lined with a 7-inch

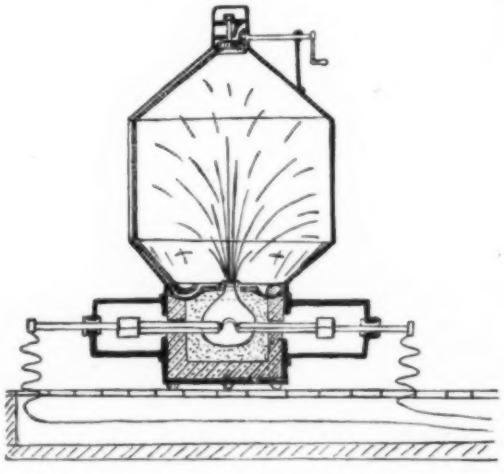

FIG. 1.—MONOX FURNACE.

wall of fire-brick. Diametrically opposite each other are cast-iron terminal boxes for introducing the electrodes.

The terminal boxes have doors provided with rubber gaskets in the form of tubes, through which water under pressure circulates, in service, insuring a gas-tight joint and keeping the gasket and adjacent metal surfaces cool at the same time. These water-cooled expansion gaskets are used in a number of places about the furnace and contribute in no small degree to its success, as they do away entirely with bolts, nuts, and washers, asbestos gaskets and all the time-wasting details of what may be termed standard practice. The doors are shut and the water turned on, and that is all there is to a making a gas-tight fit. When the doors need to be opened, the pressure is equalized inside and out, the water turned off, and the door opens as easily as though it were on a kitchen range.

The electrode clamps are also water-cooled, as otherwise the bolts and nuts get so hot as to stretch and jam. It is the best practice to water-cool all parts where any mechanical action occurs. The electrodes themselves are 4-inch square bars of either Acheson graphite or carbon. These are horizontal and meet in the center of the large brick-lined drum.

The top of the drum is open and a balloon cover fits upon it with a water-cooled expansion gasket to make it tight.

The cover is a boiler-plate cylinder 7 feet in diameter, with a conical top and a conical reduction where it joints the drum.

Within the cover are scrapers which hang from a central spider in the top of the cover and are driven by gears operated by a shaft entering through a stuffing box. The cover is cooled by a film of water which trickles down over its outer surface and is caught in a gutter below. It does not heat up very rapidly and a little water serves to keep it cool enough.

The charge consists of a mixture of sand and coke, or sand and carborundum fire-sand, to which a little coke is added to increase the yield.

The drum is entirely filled with charge to a height of 12 inches or more above the electrodes. The top of the charge is then weighted down with fire-brick, and directly above the arc a graphite ring with a 7-inch opening in its center is laid on the charge and a part of the charge dug away through the ring to make a weak place in the charge so that the reaction gases shall blow out through the ring and thus build the throat in the axis of the furnace. Once the furnace is charged and has been operated, it can be recharged by pouring fresh charge down the open throat.

For providing a vacuum, an air pump of the Abbe Engineering Co. is used.

A very interesting accessory is the special generator which supplies energy to the furnace. It is a rotary field alternator designed to operate a single arc of the full capacity of the machine at or near the top of the volt-ampere characteristic curve of the dynamo. It is separately excited, and can be open circuited or dead-short circuited without injury to itself and without stalling the gas engine driving it.

This generator was designed by Mr. Tingley, of the Westinghouse Electric & Manufacturing Co. particularly for this service, and it may be said to be the first of an intermediate type of dynamo between the constant-potential and constant-current types. This may be appropriately termed the electric furnace type, as its peculiar virtue is to maintain an arc without any necessary regulation external to the armature.

Analysis of Silicon Compounds.

Mr. A. BLISS ALBRO presented a paper on a new method for the analysis of silicon compounds. This method has been devised by the author in connection with Dr. Potter's work, and in practical use for a number of years it has proven thoroughly reliable.

The author first discusses a number of disadvantages of the usual sodium peroxide method. Among these are the following two, if the silicon analyzed contains carborundum. Since the latter is dissociated by sodium peroxide with the liberation of carbon dioxide, no distinction can be made between any free carbon in the sample and the carbon from the silicon carbide without a separate analysis. Further, the silicon from the carborundum passes into the fusion the same as the free silicon and is credited as existing in the sample in the elemental state.

Since it is impossible to give in a brief abstract all the elaborate steps in Mr. Albro's new method (for which reference must be had to his paper in full to be published in the *Transactions*), we will simply notice here Mr. Albro's simpler method for checking the impurities contained in silica, silicon monoxide, or ferrosilicon.

After proper sampling and weighing in a platinum dish of about 75c.c. capacity, the sample is moistened with distilled water and then treated with about 30 c.c. of concentrated c.p. hydrofluoric acid and 10 c.c. of concentrated c.p. nitric acid. The hydrofluoric acid is added first, and then the nitric acid is added drop by drop, owing to the violence of the reaction. After all reaction has ceased, the solution is diluted and filtered through a weighed, hardened filter paper. This is dried and weighed, the gain in weight being a true measure of the free carbon and silicon carbide in the sample. It is then incinerated, the loss in weight after correcting for filter paper ash being free carbon and the residue silicon carbide.

The filtrate is caught in a platinum dish, evaporated to dryness, treated with a few drops of sulphuric acid, re-evaporated, taken up with sulphuric acid, to which a small amount of hydrochloric acid is added, heated to boiling, diluted with distilled water, boiled until a clear solution is obtained, evaporated until copious fumes of sulphuric acid are given off, diluted with distilled water and treated to determine the iron, aluminium, calcium and magnesium. By adding ammonium chloride and ammonia, boiling and filtering a precipitate is obtained which contains the iron and aluminium as hydroxides, while the filtrate contains the calcium and magnesium. The silicon is finally calculated by difference.

This analysis has been proved to be accurate to within 0.3 to 0.4 per cent. of the total silicon content of commercial silicon and silicon compounds, as compared with the results obtained by the longer method of Mr. Albro. This method is especially useful in analyzing ferrosilicon containing less than 75 per cent. of silicon. The results always show slightly higher silicon values than actually exist, owing to the fact that all the material volatilized by the mixed acids appears as silicon in the final result.

Determination of Silicon.

Mr. WILLIAM ROY MOTT presented a paper on electrochemical methods for the qualitative and quantitative determination of free silicon in the presence of silica, silicates, oxides, free carbon and silicon carbide. A direct process for determining free silicon consists in the treatment of the material to be analyzed with metallic fluorides, such as copper fluoride, silver fluoride, etc. In one step the solid metallic silicon electrochemically replaces the metal in solution, which metal is deposited and may then be weighed or may be dissolved and determined in any regular way. These methods are direct, and are not interfered with by the presence of silica, silicates, metallic oxides, free carbon or silicon carbide.

In the case of silver the formation of pure solution of silver fluoride with hydrofluoric acid is advisable. The material to be analyzed can be ground in an agate mortar, which will be partially abraded, as silicon carbide is the harder material, but this, however, does not interfere with the accuracy of the result as it does where chemical methods for determining free silicon are used. To determine the total free silicon in the material it is only necessary to grind fine enough to pass sieve No. 150.

The treatment with silver fluoride solution should be made in a platinum dish and continued from 1 hour to a day. The reaction of silicon in electrochemically-precipitating metallic silver is $Si + 4AgF = 4Ag + SiF_4$. One atom of silicon replaces four atoms of silver. The author has made quantitative determinations where the free silicon formed only about one millionth part of the material analyzed.

Electrometallurgy of Iron.

Two papers presented at the Thursday meeting dealt with the reduction of pig iron from ore in the electric furnace.

The first paper, which had Messrs. A. E. GREENE and F. S. MACGREGOR as joint outhors, was presented by Mr. MacGregor, and gave an account of the authors' research, which has already been fully covered in an article by the same authors in our September issue, page 367.

Mr. Greene is now with the Noble Electric Steel Co., in Héroult-on-the-Pit, Shasta County, Cal. As will be remembered this company is to carry out, on a large commercial scale, the reduction of California iron ore in the electric furnace, cheap electric power from water-power being available. The pig iron is subsequently to be made into steel. According to a statement of Dr. Héroult this will be done simply in an open-hearth furnace, since the pig iron and steel produced will be pure enough to make final steel refining in an electric furnace unnecessary. Several successful runs for producing

pig iron in the electric furnace have been made, but until the plant for making the electrodes is completed the company will make only ferro-silicon on a commercial scale.

The second paper presented on the electric reduction of iron ore was a discussion by Dr. Joseph W. Richards of the experiments which were made at Sault Ste. Marie with the Héroult furnace, under the auspices of the Canadian Government, and a detailed account of which may be found in our Vol. IV. Unfortunately, no advance copies of the very interesting paper of Dr. Richards were available, so that it is impossible to give here the numerous thermochemical calculations which were presented by the author in form of tables, etc. However, some fundamental general points were brought out strongly in the paper.

One is that there is no advantage in trying to produce in the electric furnace a pig iron containing a certain amount of silicon. By doing so the two different problems of iron oxide reduction and silica reduction are mixed up. It is preferable to simply reduce the iron oxide, and later on add any silicon which may be desired in form of ferro-silicon.

A second and even more important point brought out by Dr. Richards was the necessity of properly proportioning the amount of carbon in the charge. Since in the electric furnace carbon acts simply as a reducing agent, and since in a given charge of ore there is only so and so much iron oxide, the oxygen of which can combine with the carbon, it will be evident that so much carbon should be used as is able to combine with the oxygen in the ore to form carbon dioxide. If more carbon is used some carbon monoxide will be produced, and the amount of carbon monoxide in the gases will be the higher the greater the proportion of carbon in the charge. To control the proper working of the furnace it is of the highest importance to analyze the furnace gases, and this has been generally neglected in experimental researches of this kind. This is a matter to which far more attention should be paid in future.

It also follows directly that within certain limits the less the amount of carbon in the charge the higher is the utilization of its calorific value in the electric furnace, and therefore the smaller the amount of electrical energy required. It seems that in the tests at Sault Ste. Marie generally too much carbon was used.

We hope to come back to Dr. Richards' interesting analysis more in detail in a future issue.

Mathematics of the Induction Furnace.

A paper by Mr. Gustave Gin, of Paris, on the theory of the induction furnace was read in abstract. In the first part of his paper Mr. Gin gives the fundamental formulas of a transformer with large leakage fluxes. The formulas are applied to show how the power factor in the primary and the power consumed in the secondary vary when the resistance of the secondary increases from zero to an infinite value. It is shown that for a certain value of the secondary resistance, the power consumed in the secondary is a maximum. In the second part of the paper Mr. Gin makes an attempt to calculate the various stray fluxes if the double magnetic circuit consists of two rectangular iron frames, placed vertically side by side, the secondary encircling the two vertical inner legs. Two primary windings are used in series, one on each frame. Mr. Gin considers the following two cases; in the first the two primary windings are placed on the outer vertical legs of the two frames; in the second they are placed on the upper horizontal arms. From his formulas Mr. Gin concludes that the latter arrangement is preferable. Another conclusion is that it is preferable to connect the two windings in series instead of in parallel.

In the discussion which followed the inherent necessity of having the secondary at a considerable distance from the primary was referred to. Mr. Carl Hering pointed out that the effect of the heat on the primary windings is not the most serious point, since it is possible to use asbestos-insulated and water-cooled coils, but the high temperature has a very detrimental effect on the iron forming the magnetic circuit in lowering the permeability. Dr. E. F. Roeber thought that for the sake of getting a working theory of the induction furnace, it would be preferable to start with the well-known formulas of the induction motor. Both the induction furnace and the induction motor are special cases of the general transformer, and they have in common the special feature of high-leakage fluxes. How far it is possible to take over bodily the formulas of the induction motor to apply to the induction furnace, must be determined experimentally.

Electrometallurgy of Zinc.

A paper on this subject by Mr. Gustave Gin, of Paris, was presented in abstract by Dr. J. W. Richards. The author first discusses the imperfection of the present methods in zinc metallurgy, and gives a review of various proposals which have been made as to the use of electrolytic or electric furnace methods in the metallurgy of zinc. He then gives an account of his own work in this field.

Mr. Gin first tried an electric furnace with electrodes, but he found the difficulties in using the electrodes in a closed vessel to be so great that he concluded to adopt the induction furnace for his purpose. "Suppose that in the channel of the induction furnace there is placed a metal in the state of fusion. Any material put in contact with this metal will be decomposed if it is able to form with the same another compound more exothermic than the first. It is thus possible with a given metal to set other metals at liberty. If the metal set free is capable of alloying with the first their alloy will result. If the metal set free is volatile it can be collected by condensation. This is the case when zinc oxide and sulphide are reduced by iron at a temperature above 1,300°. It is equally possible to limit the action of the iron to that of a conductor and producer of heat, and to utilize this heat to provoke reducing reactions in the mixture of carbon and metallic oxide or silicate, or of carbon, lime and metallic sulphide."

In order to get efficient circulation, Mr. Gin modifies the ordinary construction of the induction furnace by using as his crucible a series of channels, the bottoms of which are inclined longitudinally, the deepest part of each being connected by a conduit with the more shallow part of the next channel. The channels have a relatively large section so that the fused material, while filling completely the conduits or connections from one channel to another, only occupies a part of the sections of the channels themselves.

The quantity of electric energy transformed into heat varies inversely with the section of the conductor; the molten mass is for this reason cooler in the top parts of the channels than in the other extremity. By reason of the difference of temperature, and consequently of density, there results an ascensional movement of the liquid in the connecting conduits, reinforced by the further heating in the conduit itself, and by reason of this produces a general circulation throughout the whole mass, forming the secondary circuit.

The construction of the furnace is shown in Fig. 2, in which diagrams I., II., III. are vertical sections and IV. a horizontal section. The channels with exposed surface, called the working channels (a), are placed parallel to each other, their bottom longitudinally inclined and united to conduits (b) of circular section, called the heating conduits, which have the lower parts of each channel in connection with the more shallow parts of the following channel.

The primary circuit is composed of an insulated copper coil around the upper horizontal branches of the double magnetic circuit (cc). The two coils constituting the primary (dd) have the same number of turns and are connected in series.

The secondary circuit is constituted by the bath of liquid iron contained in the channels (a) and the conduits (b).

To protect the conducting cables from the radiation of the

hot masonry there are interposed between the inside faces of the magnetic coil and the adjacent masonry, metallic channels (e) cooled by a current of water. The masonry does not rest directly on the lateral faces of the inductor, but is supported on plates which themselves rest on pins. The water for cooling passes between these plates and the inductors.

A fan is used to send a current of air around the magnetic core and the primary winding, so as to keep them cool. The air is led in through trunnions (f) and is distributed by the boxes (g). Dampers, movable by chains, pullies and an endless screw, permit a regulation of the circulating air and its proper distribution. The whole furnace is contained in a sheet iron shell resting upon two trunnions (f).

The lining of the furnace is formed of burnt dolomite, agglomerated by pitch and stamped in like the hearth of the Siemens-Martin furnace. The roof is made of bricks of burnt magnesite, the contraction of which is practically nothing.

The bath of iron being at a suitable temperature, there is spread upon its surface by a charging device, similar to that used for charging gas retorts, a mixture of the oxide of zinc and carbon or of the sulphide, lime and carbon. When the charging is done, the working door is quickly closed and the joints plastered up with clay to prevent the entrance of air. Continuing the heating the temperature of the mixture is raised rapidly and the distillation of the zinc commences.

Zinc vapor and the oxide of carbon escape from the working channel by the orifices (i) and pass to the condensing chambers (m) and (n). In the chamber (m) the mean temperature is normally about 500°, but below 700°, so that the condensation to the liquid state takes place easily upon its upper wall

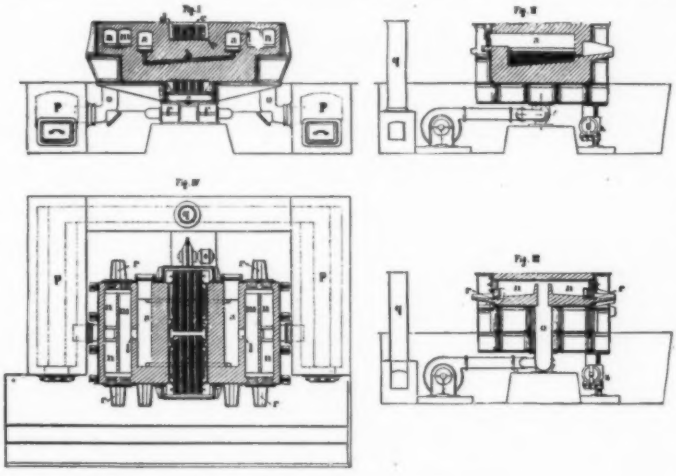

FIG. 2.—ZINC INDUCTION FURNACE.

and upon the wall opposite to the point of entrance of the vapors; the uncondensed vapors are finally brought down in the chamber (n). Any zinc oxide and dust carried along by the carbon monoxide pass along into the conduit (o) and are deposited in the dust chambers (p) which connect with a common chimney (q).

When the reduction is finished the condensed zinc is run out by opening the tap hole (r) and inclining the furnace to one side by means of the motor-driven jack-screw (s).

Finally the residues are scraped out of the working door by the use of a metallic rabble.

The heating is not interrupted during the tapping of the zinc or the cleaning out of the residue, so that one-half at least of the furnace is always active.

The circulating induction furnace provides a perfectly closed space in which the heating is effected, and not through a wall or partition as in the present furnace, but by direct contact of the mixture to be reduced with the metal in which the Joule effect is produced. Besides, the mixture with carbon, especially when it contains blende which is conducting, is of itself the seat of the development of electric heat to a not unimportant degree.

It is therefore possible with this electrothermic heating to use distillation capacity as great as one wishes, this capacity being limited only by the power of the electric furnace. At the same time the expense of refractory material is very much reduced, the hand labor is less than in the old furnace with the small muffles, and finally the loss of metal by incomplete reduction, by cracking of retorts, by reoxidation and imperfect condensation, is reduced to a minimum, far below that obtained in a furnace heated by coal or gas.

A large part of the paper contains estimates of the economic value of the process. Mr. Gin first estimates the energy necessary to reduce zinc compounds and finds that in a furnace with a thermal efficiency of 65 per cent the energy required for the reduction of 1 ton of zinc from the oxide is 2,472 kilowatt-hours, from the carbonate 4,330 kilowatt-hours, from the silicate (using lime and carbon) 4,000 kilowatt-hours and from the sulphide (using lime and carbon) 2,965 kilowatt-hours. On account of the high cost of electrical energy it is advisable to previously calcine the ore in order to transform the carbonate of zinc into oxide.

Under the same assumptions as made above Mr. Gin estimates that the energy necessary to reduce one ton of zinc from a calcined calamine is 3,560 kilowatt-hours and from sulphide ore 3,960 kilowatt-hours. He then refers to the treatment of argentiferous sulphides and the application of the process to a complex silver ore.

"For mixed ores, the method of operation may be advantageously modified to utilize the volatility of the sulphides of lead and zinc. The sulphide of lead volatilizes at about 1,000°. In the presence of carbon the sulphide of zinc also volatilizes at about the same temperature. Under the same conditions, the sulphide of iron remains fixed and unaltered. The method of treatment may consist of the following steps: first, separation of the sulphides of lead and zinc, and, second, reduction of the sulphides of lead and zinc."

The first operation may be effected in a Gin circulating induction furnace in which the two working channels are connected with the two condensers.

The ore is mixed with carbon in excess of that required by the following reaction:

$$2ZnS + C = 2Zn + CS_2$$

The mixture of lead sulphide, metallic zinc and sulphide of carbon is led into the condensing chambers, where the reverse reaction to the above takes place, so that now the zinc is resulphurized, and carbon black forms. The mixture of sulphides is collected, lime and carbon are added, and the whole is heated in a similar furnace for the reduction and condensation of the zinc, as previously described. The slag obtained is simple sulphide of calcium. When the reduction is completed in one channel, the zinc is tapped out, the working door opened, and air is admitted, oxidizing superficially the sulphide of calcium to sulphate, increasing its fusibility, and the liquid slag may be easily run out.

The sulphide of silver is volatilized with the other sulphides, except a quite small quantity which is dissolved by the bath of cast iron, and from which it may be regained by treatment of the iron with lead when the iron is sufficiently saturated.

The method of operation may be still further modified by burning the vapors of the sulphides as they issue from the furnace, and thus forming sulphates and oxides of lead and zinc, which react one upon the other in such a manner as to produce, in the condenser, part of the lead in the metallic state

containing all the silver, and a mixture of sulphides and oxides of lead and zinc with some basic sulphate of zinc. The oxidized compounds of lead and zinc thus obtained may be taken to the reducing furnace, mixed with lime and carbon, and then reduced.

This oxidation of the products coming from the furnace reduces slightly the energy requirements, and the lime required in the subsequent reduction by some 50 per cent.

Finally Mr. Gin estimates the cost of zinc production from calamine or blende in a large works having ten electric furnaces of 1,000 h.p. each, when hydroelectric power is available. He assumes that with the electric process the profits would be almost double those of the present processes. His final conclusion is as follows:

"The electric furnace processes are clearly superior to present methods. They require less expense for labor and distilling apparatus, the operation is continuous, and the losses are very notably reduced. They permit the direct reduction of sulphide ores and the treatment of complex ores.

"It may be stated, with all certainty, that such countries as Sweden, in which are united in the same region considerable quantities of complex ores with powerful waterfalls, are just suited for the adoption of electrothermic methods.

"The case is similar with the famous ores of Broken Hill, in New South Wales, which may be treated by utilizing the waterfalls of the Blue Mountains or of the Liverpool Chain. They might also be treated in New Zealand, where there are powerful waterfalls.

"The importance of this electrothermic application is emphasized by the fact that there are at Broken Hill, besides the rich ores, nearly 500,000 tons of tailings, containing 100,000 kilograms of silver, 26,000 tons of lead, and 90,000 tons of zinc.

"Similarly, the ores of Tunis, Greece and Sardinia can be advantageously treated by the use of the large water-power available in the French and Italian Alps.

"These examples are not the only ones which could be adduced, but they suffice to prove the immense interest attaching to the subject, and the unquestionably great value of successful electrothermal processes for treating such ores."

In the discussion which followed, Mr. Carl Hering remarked that by the peculiar construction which Mr. Gin has chosen in order to get circulation he invites the "pinch phenomenon." Mr. Woolsey McA. Johnson and Dr. J. W. Richards criticised some special points in the estimates of cost.

Chlorine in Metallurgy.

Mr. Charles E. Baker of Cleveland presented a paper on "A New Application of Chlorine in Metallurgy." Since in the electrolytic production of caustic soda and chlorine from common salt the caustic soda covers more than the cost of the process, the chlorine may be considered to cost nothing. Mr. Baker endeavors to use the chlorine for the extraction of metals from refractory ores, described in the paper as sulphides.

The finely pulverized, practically dry ore is placed in a poreclain-lined tube mill provided with lead-lined trunnions, and supplied with flint pebbles. This mill is considered to be necessary for the prosecution of the work. "We know of no other means for completing decomposition, especially in handling zinc sulphides." The chemical action generates so much heat that the chloride formed becomes melted, or volatilized, and spreading to surrounding particles, covers them over as by a varnish, preventing further action by chlorine. As the drum revolves, the flint pebbles grind the particles, presenting continuously fresh surfaces to be acted on. They also tend to break up or prevent any clodding or balling of the mass. The gas is admitted to the drum, and acts at once on the ore. The metal combines with the chlorine, liberating the sulphur.

As the chemical attraction of chlorine is greater than it is for sulphur, sulphur chloride is only formed as the metal contents decrease. The drum revolves during the operation, and chlorination of the metals is effected, leaving sulphur free with the gangue, provided no heat is applied and the supply of chlorine stopped when the metal is chloridized. But if the drum be heated, sulphur chloride is formed, and at about 150° C. is expelled as a gas, and may be condensed. It makes a by-product of much more value than sulphur, being salable at 10 cents per pound.

The process *proper* ends here. We have the chlorides, and the sulphur has been eliminated from its combination, and made available for revenue.

If the process be illustrated as applied to a lead-zinc sulphide ore, carrying gold and silver, the contents of the drum after chlorination would be emptied into leaching tanks, the soluble chlorides removed, leaving behind in the gangue with the free gold any insoluble silver or lead chlorides remaining. In the presence of plenty of other chlorides they are both partly soluble, and in most cases they will be carried forward with the other solutions. During chlorination, the iron forms ferrous chloride, and gold will not become soluble in its presence, nor when chlorine is dry. The gangue, freed from all base metals, and containing the free gold, is in fine condition for gold extraction, much better than if from a roasted ore. It may be recovered by wet chlorination, by cyaniding, or by amalgamation in barrels. It will be too fine for *plate* amalgamation. Silver may be recovered by leaching with sodium hyposulphite. Purification of solution follows. Granulated lead precipitates copper, granulated zinc precipitates lead. The remaining solution would then contain ferrous and zinc chlorides. Chlorine must be supplied to make the iron ferric chloride, then zinc oxide precipitates ferric hydroxid, forming zinc chloride. Electrolysis then produces practically pure zinc, and the chlorine is liberated for use again.

Suppose the ore handled be one whose principal ingredient is copper. It chloridizes as cuprous and cupric salt, either or both. If it should be cuprous, it is then only partially soluble But it is readily soluble in other chlorides, especially of sodium or calcium. Electrolysis then produces copper, liberating chlorine, the iron chloride remaining undecomposed, at the low voltage used in copper electrolysis. No deposit of copper takes place until the cathode department becomes cuprous. In a large plant in Germany where a matte is being handled, the chloride solution contains copper, iron and zinc. Copper and zinc are being produced from the same solution on a large scale, each practically pure. Last year's zinc output averaged about 2¼ cents per pound above the market price for spelter, owing to its purity.

"You are no doubt familiar with the Swinburne-Ashcroft method of handling ores by chlorine under pressure. It produces, by chemical action alone, a temperature of from 600° to 700° C, but is limited in its application to ore carrying not over about 30 per cent gangue, *i. e.*, to concentrated material The difference between their system and this is apparent. Much gangue would block them off mechanically, while we prefer having the gangue to keep down the temperature, to avoid volatilizing the chlorides. In their case sulphur vaporizes."

"Here is an illustration of an application of chlorine in the form of hydrochloric acid as the chloridizing agent. The silicate of nickel-aluminium-magnesium-iron, forming the garnierite ore found in New Caledonia, presents an almost impossible smelting proposition, as the main ingredient is magnesia. It can readily be handled by hydrochloric acid, and, after chloridizing, the acid is recovered from the base metal chlorides by calcination and used again, the nickel only retaining chlorine. We worked this process out to apply on a similar ore, found in North Carolina, and it will also apply to another deposit found in Oregon.

"The calcination of the chloridized silicate drives off the hydrochloric acid, and at the same time renders the gangue granular and readily leachable. This is an application to an ore carrying only about 1½ per cent nickel with 15 to 25 per

cent magnesia. Smelting such would be impossible, yet the expense was light, because the consumption of hydrochloric acid was, in the end, limited almost to the requirement of the nickel for its chloride. From the nickel chloride so formed we produced metallic nickel electrolytically, recovering the chlorine. No smelting at any stage.

"In commercial practice, it will be found that 2 kilowatt-hours will produce about 1 pound of chlorine, zinc, iron or nickel, and about 4 pounds of copper or lead. In the case of lead, these figures are derived from the electrolysis of the fused chloride, where some of the energy was used to maintain fusion.

"It might be proper to name some of the advantages of this method as compared with smelting. Roasting is avoided, with its expensive furnaces and suits for damages from the poisonous gases evolved. Concentration is avoided, with its expensive machinery and power requirement, and with its losses of 15 to 20 per cent of the values. The sulphur is recoverable for market. Volatilization and slagging losses do not occur. Any refractory ore can be rendered free milling, with the sulphur so thoroughly eliminated that the per cent of extraction would very high. In the case of tellurides, tellurium chloride goes into solution and is leached away, leaving the gold free in the clean gangue.

"In nickel-cobalt ore, the cobalt can be precipitated as a hydroxide from its chloride as a step preceding the nickel electrolysis. Its advantage in handling the cobalt-nickel arsenides of Canada is apparent. At present, mine owners get little beyond a reduced proportion of the silver content, but the arsenic and antimony should be saved as commercial products."

Electrolytic Reduction of Nitric Acid.

A paper by Dr. HARRISON E. PATTEN, of the Bureau of Soils, Washington, dealt with the electrolytic reduction of nitric acid, studied mainly from the standpoint of the yield of ammonia.

In order to get a view of the initial electrode potential in the solution, single potential measurements were made, using different metallic cathodes. These, together with the decomposition voltage measurements of Flaschner, help to give an insight into the reactions which may be expected under actual conditions of electrolysis.

A series of experiments, using a copper cathode with a porous cup diaphragm and lead anode in dilute sulphuric acid, was first made to ascertain the effect of the concentration of sulphuric acid upon the yield of ammonia and of hydroxylamine, discharge potentials being taken at the cathode during the process of electrolysis. The results confirmed those of the earlier investigators to the effect that the yield of ammonia increases with the concentration of sulphuric acid, while the yield of hydroxylamine decreases.

The effect of current density upon the yield of ammonia and of hydroxylamine at a copper cathode was then determined, using a porous cup diaphragm for the cathode chamber, the anode being lead in dilute sulphuric acid. Here also cathode discharge potentials were taken. The results show that increase of current density decreases the yield of ammonia at a copper cathode, while when using a platinum cathode, the reverse is true.

The effect of temperature upon the yield of ammonia and of hydroxylamine at a copper cathode, was found to be so slight as to render rigid temperature control in the experiments carried out unnecessary.

The effect of dissolved copper upon the yield of ammonia at the copper cathode and at an amalgamated copper cathode was next studied, and for comparison experiments were made with no copper sulphate present, using on the one hand a pure copper cathode, and on the other hand a pure mercury cathode. It was found that the yield of ammonia is very greatly increased by the continual deposition of copper at the cathode. The suggestion made by Tafel that this effect is due to a cathalytic action of the deposited spongy copper, is open to question, since this same effect is produced when the copper is in similar manner continually deposited upon the amalgamated copper cathode, whose surface remains smooth throughout the reduction. These experiments have a very interesting bearing upon the theory of the "nascent state." There is a maximum point for this effect. Thus, when nitric acid is reduced at a copper cathode in a solution very highly concentrated with respect to copper sulphate, the yield of ammonia is less than is obtained with more dilute solutions. This same effect was obtained by Ingham.

The results of former investigators upon the effect of the cathode metal in determining the yield of ammonia and of hydroxylamine in the reduction of nitric acid have been confirmed by the author, and in addition it is shown that a low cathode discharge accompanies a high yield of ammonia when the current density is the same. Further, several reductions were made in alkaline solutions and the anode and cathode discharges taken, together with the yield of ammonia, for platinum, zinc and copper cathodes, using a small platinum anode.

To ascertain whether nitrogen or nitrogen oxides may be liberated at platinum anode and copper cathode during the electrolysis of potassium nitrate in the presence of sulphuric acid and copper sulphate, the anode and cathode gases were collected and analyzed, and the discharge potentials read from time to time during the electrolysis. It was found that nitrogen, either as free nitrogen or in the form of oxides, was given off at both the copper cathode and the platinum anode.

To test the definite statements of Tafel and others that hydroxylamine is not reducible at a copper cathode, hydroxylamine hydrochloride was electrolyzed in 1.7 per cent sulphuric acid solution at a copper cathode and 58.8 per cent of the total nitrogen recovered as ammonia; in similar manner with copper sulphate present in the solution, 65.3 per cent of the total nitrogen in hydroxylamine was converted to ammonia. These experiments, together with those of Flaschner, recently published, make it evident that the reduction of nitric acid to ammonia at a copper cathode may, and probably does, go through the hydroxylamine stage.

Finally it was shown that electrolysis of sodium nitrite at a copper cathode in sulphuric acid solution reduces all of the nitrogen to a form not oxidizable by potassium permanganate. Fifty-nine per cent of the total nitrogen present as nitrite was converted to ammonia and recovered.

Determination of Copper.

A paper by Mr. E. E. FREE, of the Agricultural Experiment Station in Tucson, Ariz., dealt with the determination of minute quantities of copper. The determination of quantities of copper less than 1 milligram cannot be carried out by the ordinary procedure of electrolytic analysis, because of the impossibility of weighing with sufficient accuracy the dishes or other cathodes usually employed. Phelps avoids this difficulty by precipitating the copper electrolytically, dissolving the deposit and estimating it colorimetrically. By the use, however, of the electrode described by the author the colorimetric determination may be dispensed with and the copper weighed directly as deposited, a fair degree of accuracy being obtainable with quantities of copper as small as .05 milligram.

FIG. 3. ELECTRODE.

The electrode is made from a small piece of platinum wire bent into a spiral with one end extending along its axis. It is supported in the bath by wrapping this free end four or five times about a hook of heavy platinum wire. If the hook be straight and slightly tapered toward the point the electrode may be easily attached and removed and makes perfect contact with the hook. The whole arrangement is shown

in Fig. 3. The electrode used by the author weighed about 0.3 gram.

The extraction and concentration of the copper are carried out by the usual methods. The electrolysis may be made in either nitric or sulphuric acid solution, low currents being used on account of the small cathode area. The author uses 2 per cent to 4 per cent nitric acid and a few drops of sulphuric acid in about 25 c.c. solution and electrolyzes over night with about 1.8 volts and 0.01 ampere. The containing dish serves as anode.

Boiling Points of Metals.

A paper by Dr. Oliver P. Watts dealt with "the metals in order of their boiling points as arranged from Moissan's experiments in the distillation of metals and alloys."

The widespread introduction of the pyrometer into both scientific and technical metallurgy has resulted in an increase in the accuracy and extent of our knowledge of the melting points of the metals. Their boiling points, however, are still an almost unknown quantity. A knowledge of the latter is of importance to the experimenter with the electric furnace, for in the production of metals from their ores the boiling point of the metal fixes the maximum temperature of the furnace, consistent with a good yield.

Although it would be most satisfactory to have the boiling points of the metals expressed in degrees centigrade (or Fahrenheit), it is not necessary that they be so stated in order to be of service in electric furnace work. An arrangement in order of their boiling points, with some indication of the magnitude of the intervals between successive members of the series, would be of practical use.

Dr. Watts gives a concise summary of the various determinations made by Moissan, and finally presents his attempt to arrange the entire series of metals treated in order of their boiling points. "This is a difficult task to accomplish satisfactorily, and probably an impossible one to carry out with complete accuracy. In several cases the difference between the weights of two metals distilled is within the limit of experimental error. The specific heats and unknown latent heats of vaporization may also cause errors in the tabulation, as the writer could not make allowance for these factors. The only known points in the series are the boiling points of zinc, 940° C., and copper, 2,100° C., as determined by Féry. The boiling point of tungsten was then assumed to be 3,700° C., and the other metals were arranged between these limits.

"The number standing opposite each metal is not claimed to be its boiling point, but only as an indication of its relative position in the series which begins with zinc at 940° C., and ends with tungsten at some unknown temperature above the melting point (3,200° C.).

Zinc	940° C.	Titanium	2,700° C.
Cadmium	1,025	Rhodium	2,750
Lead	1,250	Ruthenium	2,780
Silver	1,850	Gold	2,800
Copper	2,100	Palladium	2,820
Tin	2,170	Iridium	2,850
Manganese	2,200	Osmium	2,950
Nickel	2,450	Uranium	3,100
Chromium	2,500	Molybdenum	3,350
Iron	2,600	Tungsten	3,700
Platinum	2,650		

"The order for the first six metals with reference to each other is correct, since it was obtained from the distillation of alloys. The position of manganese with reference to tin and copper is doubtful. Gold is surprisingly high in the series, and if correctly placed, is second only to tin in the wide range of temperature of its liquid state. Further and more conclusive experiments may lower the position of gold. Moissan's experiments show that there is considerable vaporization of titanium before it melts, but even so, the low position here necessarily assigned for its boiling point must be a surprise to anyone who has tried to fuse this extremely refractory metal. The writer thinks that further experiments, particularly in the absence of air, may greatly change the place of titanium."

In the brief discussion which followed Dr. J. W. Richards remarked that in making use of the determinations of Moissan one should take into consideration that the metals were distilled from alloys and not from pure metals.

Granular Carbon Resistors.

A paper on this subject by Messrs. S. A. Tucker, A. Doty and R. W. Cauchois was presented by Prof. Tucker. In the use of granular carbon for resistance material in the electric furnace many varying conditions may exist, dependent on the size of the carbon grain, the compression to which the grains are subjected and the number of times the material has been employed as resistor.

It has always been noticed in using an electric resistance furnace that at the beginning of the run with new ground coke as resistor, although a high e. m. f. is impressed across the terminals of the furnace, yet the current is small on account of the high resistance of the "green" resistor material. After a little while the temperature of the furnace rises and a large quantity of gas and fumes is given off by the resistor. (In one of the experiments of the authors, using direct current, the smoke appeared first at the positive terminal, then in the center of the resistor, and finally at the negative terminal.)

This condition of gas evolution prevails for some time while the resistance of the furnace and the current vary very rapidly. If a sufficiently high e. m. f. is impressed on the terminals of the furnace and maintained constant, the temperatures will steadily rise until this period of gas evolution is passed and the rapid fluctuations of the resistance cease. It will then be found that as the temperature increases the resistance slowly but steadily decreases, and if the impressed e. m. f. is not rapidly cut down a large rush of current is liable to occur.

If, however, the resistor has been previously subjected to one thorough heating run, in which a high temperature in the carbon has been obtained, so that the volatile products are eliminated from the coke, the conditions existing in using the same material afterwards as resistor are far more uniform. In constant-voltage experiments of the authors it was found that when in this case the temperature rises the resistance first decreases to a minimum, then remains constant for a while and finally increases with increasing temperature.

The authors experimented with various grades of coke, passing a series of sieves of 10, 20, 30, 40 and 50 meshes to the inch, and also with a mixture of these grades. In their first experiments the authors used direct current and tested both green coke and preheated coke with variable direct current. Their next tests were made with variable alternating currents, but the results of the two sets of tests with direct and alternating current are not comparable. In order to make a definite comparison possible a series of constant-current tests were made, both with direct current and alternating current.

A comparison of watthours required to reach a temperature of about 340° with alternating current and with direct current is as follows:

Alternating Current.		*Direct Current.*	
Watthours.	*Grade of Coke.*	*Watthours.*	*Grade of Coke.*
38	50-mesh.	46	50-mesh.
35	20-mesh.	230	20-mesh.

A set of experiments was made in which an external pressure was exerted on the granular coke. The only change caused by pressure is a considerable decrease of the resistance of the coke.

While the results of the authors are given in great many diagrams and tables, the following general conclusions may be drawn from them. The results obtained seem still to leave it an open question whether a resistor material of high or low

resistance would give the most efficient results. In fact, the design of the furnace might decide this question, or whether the machine furnishing the energy was designed for low voltage and heavy currents or vice versa.

From the tests of the authors, using variable direct current, the conclusion might be drawn that a certain grade of coke was more efficient than another, but other tests made with constant current contradict these results. Also the comparative tests with direct and alternating current would mean to indicate that a greater efficiency is obtainable with alternating than with direct current.

Further, it appears that the more frequently the coke is used the lower is the temperature which may be attained by the same expenditure of energy.

Finally, the coarser the grade of coke the greater is its conductivity; and any single grade of coke is more efficient than a mixture of all grades.

The paper was briefly discussed by Dr. J. W. Richards and Mr. Carl Hering.

The Heat Conductivity of Carbon.

A paper by Mr. F. A. J. FITZGERALD discussed the comparative heat conductivities of carbon and graphite. These figures are of great importance for electric furnace work.

All electric furnaces receive their electrical energy from the outside, and with the single exception of the electric induction furnace, to which energy is supplied by means of electromagnetic induction, the current is introduced through terminals. Formerly amorphous carbon electrodes were generally used, but since Mr. Acheson succeeded in making artificial graphite electrodes of suitable form for electric furnace work, these graphite electrodes have found very extended application. One of their greatest advantages is the great facility of machining them into any shape. Another advantage is their much higher electric conductivity, so that it is possible to increase very much the current density for the same Joulean losses within the electrodes as compared with amorphous carbon electrodes.

In making calculations of this sort, it is, however, important to take into consideration that artificial graphite electrodes also have a much greater thermal conductivity than carbon electrodes, so that the heat loss from the interior of the furnace to the outside is increased. Mr. FitzGerald's experiments on this matter show that artificial graphite has a heat conductivity of 18 or 18½ times that of amorphous carbon .

The paper was briefly discussed by various speakers, and Mr. Carl Hering referred to the fact that if one has a metal rod with a crack in it, it is possible to heat the end of the rod on one side of the crack up to red heat while the other end remains relatively cool. The crack has by no means such an effect on the electric conductance of the rod as on the thermal conductance. Something of this kind could be made use of in graphite electrodes to diminish the loss of heat.

Silver Coulometer.

"Studies on the Silver Coulometer" was the title of an elaborate paper by Dr. L. H. DUSCHAK and Dr. G. A. HULETT of Princeton University. The paper was presented in abstract by Dr. Duschak.

Parallel with the work on standard cells, the authors have undertaken a determination of the electrochemical equivalent of silver, investigating the porous-cup coulometer proposed by Dr. T. W. Richards as to its reproducibility, the purity of the silver deposited and the nature of the reactions at the cathode.

Particular attention has been given to the question of weighing and a number of manipulation tests and blank experiments have been carried out in order to determine the errors and their distribution. The coulometers, as the authors used them, showed a reproducibility of one in 200,000 when the silver was deposited on platinum. With deposits on silver the results were not as good.

The question of the purity of the deposited silver has received particular attention and a method has been devised by which it has been possible to remove and directly determine the impurities instead of determining them by difference as heretofore. The silver deposit was readily detached from the cathode cup (platinum) with a spatula and brought into a vacuum apparatus which was provided with a manometer. It was found that the thoroughly dried silver gave off water and gases in vacuo. The water was condensed in a little side tube by the application of a freezing mixture and this tube sealed off and the contents determined. The volume and pressure of the remaining gases (oxygen and nitrogen) were determined.

It was found that the cathode silver from a silver nitrate solution began to give off water and gases at about 160° and on increasing the temperature more were given off. Even at 600° the silver still retained water and gases which were not all removed until the metal was melted. The total amount was small, about one part in 10,000, but they were determined for the first time directly and the method gives the qualitative and quantitative information to be taken into account in an accurate determination of the electrochemical equivalent of silver.

It was also found that the silver deposited from an air-free solution of silver nitrate weighed less than the corresponding deposit from an air-saturated solution and that this vacuum deposit also contained correspondingly less impurities.

It will also be necessary to know whether the current at the cathode is doing any other work than depositing normal univalent silver ions, and this question is now receiving the attention of the authors.

In the discussion which followed Mr. Carl Hering suggested that if platinum is used as electrode material occluded gases may have an effect and that gold may be preferable. Dr. Hulett replied that they are now making experiments with a gold electrode.

Concentration Cells.

A paper by Prof. HENRY S. CARHART and Mr. F. J. MELLENCAMP was a further contribution to the study of concentration cells. If the well-known Gibbs-Helmholtz equation, which is valid for any reversible galvanic cell or electrolytic process, is applied to the special case of concentration cells, and if we further assume that the solutions used are very dilute, so that the heat of dilution is negligible, we find that the e. m. f. of the concentration cell is given by the second term of the Gibbs-Helmholtz equation, and therefore equals the absolute temperature multiplied with the temperature coefficient of the e. m. f.

If, however, the heat of dilution is not negligible the first term of the Helmholtz equation must also be considered. Whenever the heats of dilution (reckoned from any standard concentration) of the two solutions in the two legs of the cell differ, this difference is available as energy to produce an e. m. f. represented by the first term of the Helmholtz equation. If then the temperature coefficient of the cell is positive, the e. m. f., due to a positive resultant heat of dilution, is to be added to the value of T dE/dT.

The authors have applied this principle to several concentration cells for which the heat of dilution was known. The electrolytes in the different cells were zinc sulphate, cadmium sulphate, copper sulphate and zinc chloride. The agreement between theory and experiment is remarkably good. For instance, in the case of a concentration cell consisting of $ZnCl_2$, $21.9H_2O$ and $ZnCl_2$, $386H_2O$ the free energy, due to the difference of heat of dilution, represents an e. m. f. of 0.10100 volt. The temperature coefficient of the e. m. f. is negative in this case, and the product of the temperature coefficient by the absolute temperature gives —0.02839 volt. Therefore, according to the Gibbs-Helmholtz equation the e. m. f. should be 0.0726, while 0.0751 was found by measurement. In all the other cases dealt with by the authors the temperature coefficient is positive.

Radioactivity.

A paper by Dr. Herman Schlundt dealt with the electroscopic determination of the radium present in some tufa deposits from Hot Springs, Ark. Dr. Boltwood has formerly examined the waters of these springs for radioactive properties, and found that they possess radioactivity which was due to the presence of radium emanation. Considerable variations were found in the activity of the different water samples, whose mineral constituents stand in close resemblance. No connection could be established between chemical composition of the waters and the striking differences observed in their radioactive properties. Dr. Schlundt has determined the quantities of radium present in several tufa samples from Hot Springs. The quantities found in some of the samples greatly exceed the quantity found in the particular sample tested by Dr. Boltwood. Such marked variations as the latter found in the quantities of radium emanation present in the water samples were likewise exhibited in the tufa samples examined.

Deflocculated Graphite.

Mr. Edward G. Acheson, of Niagara Falls, presented a lecture on this subject with demonstrations and experiments.

In 1901 Mr. Acheson made a series of experiments to produce crucibles from artificial graphite. This led him to a study of clays. He found that American manufacturers of graphite crucibles imported from Germany the clay used by them as a binder of the graphite entering into the crucibles. The reason is that the German clays are much more plastic and have a greater tensile strength than American clays of similar chemical composition. Chemical analysis did not give any explanation of the difference. Moreover, residual clays—those found at or near the point at which the parent feldspathic rock was decomposed—are not as plastic or strong as the same clays are when found as sedimentary clays at a distance from their place of origin.

Mr. Acheson concluded that the greater plasticity and the tensile strength were developed during the period of transportation from the place of their formation to their final bed, and thought it might be due to the presence of extracts from vegetation being in the waters which carried them. He, therefore, made several experiments on clay with vegetable extracts, tannin being one of them, and found that a moderately plastic, weak clay, when treated with a dilute solution of gallotannic acid or extract of straw, was increased in plasticity, required about half as much water to produce a given degree of fluidity, was caused to remain suspended in water, and was rendered so finely subdivided that it would pass through a fine filter-paper. On account of the story in the Bible of how the Egyptians had the children of Israel use straw in the making of bricks (the straw being used, in Mr. Acheson's opinion, not for any benefits derivable from the weak fibres but for the extract) he called clay so treated Egyptianized clay.

Mr. Acheson then referred to his more recent discovery of a process for producing fine, pure unctous graphite (see our Vol. IV, p. 502). When he began to work out the details of its application as a lubricant, he found that in the dry form or mixed with grease or oil, it was easy to handle, but Mr. Acheson wished it to enter the entire field of lubrication as occupied by oil. In his first efforts to suspend it in oil he met the same troubles encountered before by others, the graphite would quickly settle out of the oil. Then it occurred to him that tannin might have the same effect on graphite that it had on clay. He tried it with satisfactory results.

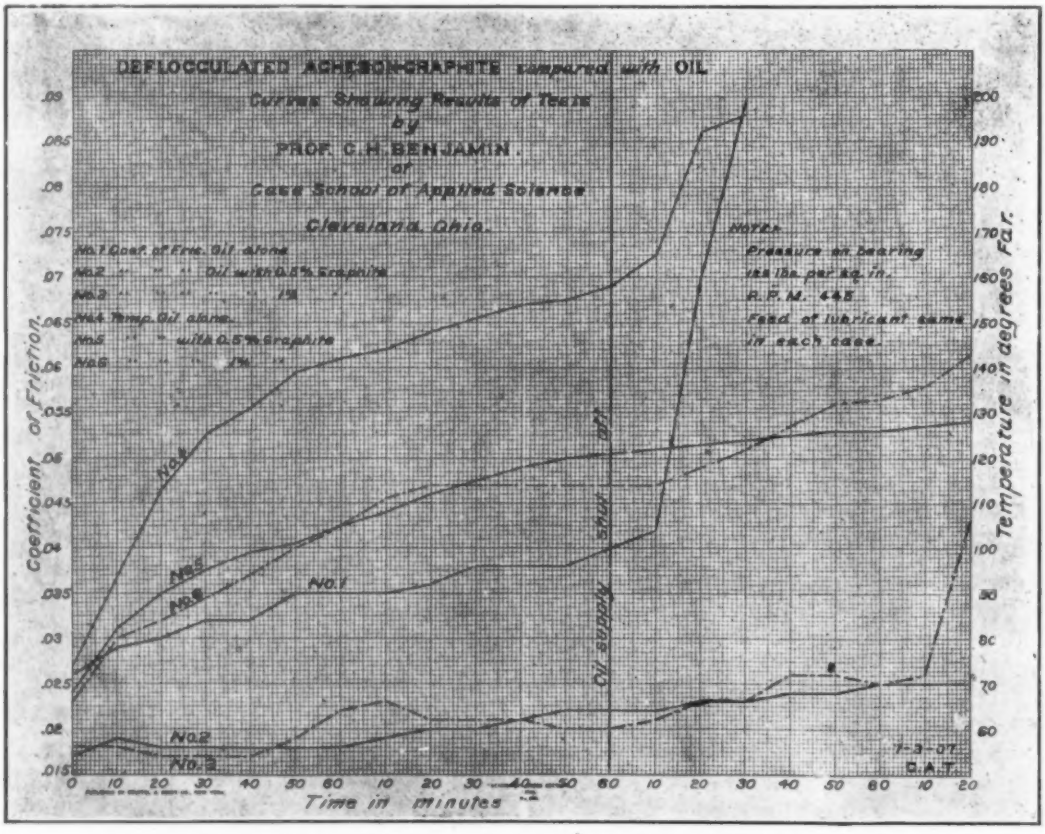

FIG. 4.—COMPARATIVE TESTS OF OIL AND OF OIL AND DEFLOCCULATED GRAPHITE AS LUBRICANT.

Mr. Acheson then made various experiments to show this effect. In one experiment he took two equal quantities of unctous graphite as produced in the electrical furnace. When

in this form he calls it disintegrated unctous graphite. To one sample he added plain water, and, after rubbing up in a mortar, he poured it into a test tube. To the other sample he added water, a little gallotannic acid and a few drops of ammonia. The ammonia is not always necessary, but improves the results with some waters. He then rubbed the mixture in the mortar as in the first case and poured into a test tube. When both tubes were shaken and then set to rest to settle, it took only a few minutes until the graphite in the plain water had completely separated from the water; on the other hand, the mixture of water, tannin, and ammonia remained black when shaken up. As a matter of fact it remains so indefinitely, and even more, the result is much improved by time.

The graphite is here in what Mr. Acheson calls the "deflocculated" condition, a condition of fineness beyond that attainable by mechanical means, a "condition approaching the molecular state." It is usual to call this condition the colloidal state. The graphite is so fine as to pass with ease through the finest filter-paper. This was shown by an experiment.

In a further experiment, Mr. Acheson introduced a few drops of hydrochloric acid into the black colloidal deflocculated graphite fluid and then slightly warmed it over spirit-lamp flame. This causes the suspended graphite to flocculate so that when the liquid is then poured onto a second filter paper, the water runs through clear, the graphite remaining on the paper. This is the well-known effect of electrolytes on colloids.

Mr. Acheson has successfully used deflocculated graphite in water instead of oil in drop-feed oilers and with chain-feed oilers. He has a shaft in his laboratory 2 5/16 inches in diameter, revolving at 3,000 revolutions per minute in a bearing 10 inches long that had no oil on it for months, deflocculated graphite in water being the only lubricant used, the feed being by chain, and it ran perfectly. On the same shaft is a similar bearing lubricated with oil; this runs much the warmer of the two.

Mr. Acheson said that a few days after this test was started a pessimistic friend of his remarked that just plain simple water might give the same results, that the presence of graphite might be unnecessary. "We are influenced by the opinions of others even when we know or think they are wrong," so Mr. Acheson emptied the oil out of the second bearing on the shaft and substituted plain water. The results during the first 12 hours seemed to support the contention of his friend. The next day after the machine had stood motionless over night things did not look so rosy for the water; it was a lame second on account of rust, and was hurriedly removed. Mr. Acheson will not recommend clear water as a permanent lubricant.

Deflocculated graphite in water possesses the remarkable power of preventing rust or corrosion of iron or steel. This graphite, even after flocculation, is so fine in its particles that when dried *en masse* it forms a hard article.

While deflocculated graphite in water is an efficient lubricant, it has the drawback of losing its water by evaporation. Mr. Acheson also appreciated that much time would be consumed in converting the world to water lubrication from the present one of oil. Therefore, he set before him the problem of replacing the water medium with oil. A very great deal of difficulty and many discouraging conditions were met with, but success was finally achieved. and it has been found that about ½ per cent of deflocculated graphite in oil is sufficient for most work.

Mr. Acheson showed in a diagram the results of tests made by Prof. G. H. Benjamin at the Case School of Science with oil alone and with oil and deflocculated graphite. The curves are shown in Fig. 4, and are almost self-explanatory.

It will be seen that the initial friction of oil and 0.5 per cent graphite was 65 per cent of that of oil alone. After 60 minutes the friction of graphite-oil was 55 per cent of oil alone. While the friction of oil alone increased in this time by 54 per cent, the friction of oil and graphite increased 30 per cent only. After lubrication was shut off the friction of oil alone increased 125 per cent in 30 minutes, while that of oil and graphite increased only 14 per cent in 80 minutes. Spindle oil was used in all tests. Curves 1, 2, 3 are the friction curves, 4, 5, 6 the temperature curves.

After the conclusion of the lecture, Mr. John Rhodin, the well-known English electrochemist, paid a high compliment to Mr. Acheson by saying that it is the Acheson electrodes which have made commercial electrochemistry possible.

Dr. H. N. Potter remarked that he had used deflocculated graphite in oil as lubricant on his automobile, and that the consumption of the lubricant has thereby been reduced to one-half.

Diamond and Moissanite—Natural, Artificial and Meteoric.

The long address presented by Dr. GEORGE F. KUNZ, the well-known gem expert of Tiffany & Co., dealt with all phases of this subject and was illustrated by numerous lantern slides and exhibits. The author discussed the properties and uses of natural diamonds varying from those exceedingly valuable as precious gems to those so useful for industrial work in diamond drills. He then discussed Moissan's well-known experiments on the production of diamonds in the electric furnace. Concerning meteoric diamonds, he mentioned the renowned block of meteoric iron from Canyon Diablo, Arizona, which was found to be somewhat heterogeneous in its structure and to contain iron, nickel, sulphur, phosphorus, silicon and carbon. The latter element was found to exist in its several forms—amorphous carbon, graphite and diamond, and Moissan succeeded in separating both the black and the transparent variety of the diamond.

In connection with these, Moissan discovered, as absolutely new, green hexagonal crystals of carbon silicide. This is the same substance which is so well known under the name of carborundum, and is artificially produced in very large quantities in the electric furnace. As this is the first instance in which carbon silicide has been proved to occur in nature, and, therefore, as a mineral, it is entitled to a distinct mineralogical name, and Dr. Kunz has thought it fit to associate Moissan's name with it and call it Moissanite. Moissanite is therefore natural carborundum, or carborundum is artificial moissanite.

Other Papers.

The concluding lecture of the Saturday meeting was presented by Dr. A. S. CUSHMAN, of Washington, D. C., on the corrosion of iron as an electrochemical phenomenon. The paper gave a summary of his researches which have already been covered in full in our July issue, pages 254 and 257, and in our September issue. pages 343 and 364. Dr. Cushman also exhibited several of his samples of steel on which the anodic and cathodic zones had been made visible in different colors by means of his special indicator. As some one remarked, "Dr. Cushman has succeeded in putting the theory into evidence in our national colors."

The following papers were either presented very briefly in abstract or read by title only:

Physico-Chemical Notes on the Alkali Aluminates. By P. B. SADTLER.

Action of Ammonium Persulphates on Metals. By J. W. TURRENTINE.

Note on the Use of the Capillary Electrometer for Alternating Voltages. By M. G. FLOYD.

Electrolytic Separation of Silver and Copper. By H. W. GILLETTE.

The Treatment of Storage Battery Elements Before Putting Them Out of Commission. By O. W. BROWN and R. R. SAYERS.

On the Nature of Electrolytic Conductors. By L. KAHLENBERG.

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Among the guests from abroad who attended the meeting we noticed Mr. John Rhodin, the well-known Swedish electro-

chemist, who is now making his home in England. He is probably best known through his mercury cathode cell.

As guests of Mr. Jacob Hasslacher, Count and Countess Andre de Riva-Berni, of Paris, and Mr. Bernard Dräger, of Lübeck, Germany, were present at the banquet. Count de Riva-Berni is the general manager of the Comptoir International de vente du Ferro-Silicium; *i.e.*, the European ferrosilicon syndicate. Mr. Dräger is part owner of the Drägerwerke, of Lübeck, which make a specialty of the use of oxygen for sanitary and industrial purposes (autogenous welding, autogenous cutting of steel plates, etc.).

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The following is a complete alphabetical list of all members and guests who registered at the meeting. Where no place of residence is given New York City is meant:

Mr. H. Abraham, Bound Brook, N. J.; Mr. and Mrs. E. G. Acheson, Niagara Falls, N. Y.; Mr. Charles E. Acker; Mr. and Mrs. Lawrence Addicks, Elizabeth, N. J.; Mr. A. B. Albro; Mrs. H. Aledambra; Mr. Jerome Alexander; Mr. A. Appelberg, Schenectady, N. Y.; Mr. Clement B. Asbury, Brooklyn, N. Y.; Dr. Leo Baekeland, Yonkers, N. Y.; Mr. A. R. Baker; Mr. Charles E. Baker, Cleveland, Ohio; Mr. E. T. Baker, Brooklyn, N. Y.; Mr. H. B. Baldwin, Newark, N. J.; Mr. D. A. Bartlett; Prof. and Mrs. C. F. Baskerville; Mr. Howard G. Bayles; Mr. F. M. Becket, Niagara Falls, N. Y.; Mr. W. B. Bishop, Brooklyn, N. Y.; Mr. F. W. Blair; Miss Katharine Blunt, Brooklyn, N. Y.; Mr. P. A. Boeck; Mr. W. D. Bonner, Princeton, N. J.; Dr. W. Bowman; Mr. George M. Boynton; Mr. C. S. Bradley; Mr. W. E. Bradley; Mr. G. Breed, Philadelphia, Pa.; Mr. F. E. Breithut; Dr. A. A. Breneman; Prof. W. H. Bristol; Mr. P. S. Brown; Mr. Wm. Hand Browne, Jr.; Mr. Irwin Buck; Mr. L. Buck; Mr. A. W. Buel; Mr. S. C. Buel; Prof. C. F. Burgess, Madison, Wis.; Mr. H. M. Burkey, Newark, N. J.; Miss M. C. Burnley, Poughkeepsie, N. Y.; Mr. Thomas Callahan; Mr. Roland Calverla; Dr. H. R. Carveth, Niagara Falls, N. Y.; Mr. C. R. Cary, Philadelphia, Pa.; Dr. W. R. Cathcart, Maywood, N. J.; Mr. G. F. Catlett; Mr. Hardee Chambliss, Brooklyn, N. Y.; Prof. and Mrs. Charles F. Chandler; Mr. Camille Cito, Newark, N. J.; Mr. A. N. Clark; Mr. W. G. Clark; Mr. E. B. Cobb; Mr. H. R. Cobleigh; Mr. H. V. Coes; Mr. H. B. Coho; Mr. E. A. Colby, Newark, N. J.; Mr. H. D. Cowles; Mr. J. S. Crider, Cleveland, Ohio; Prof. F. B. Crocker; Mr. Wm. D. Crumtin, East Orange, N. J.; Mr. Robert W. Curtis; Mr. Robert W. Davis, Jr., Haskell, N. J.; Mr. A. E. Dean; Mr. F. A. Decker, Philadelphia, Pa.; Mr. J. M. Deshong; Mr. W. A. Doerflinger, Brooklyn, N. Y.; Prof. and Mrs. Charles A. Doremus; Miss M. Dorn, Poughkeepsie, N. Y.; Mr. B. Dräger, Lübeck, Germany; Dr. W. Dreyfus; Dr. and Mrs. G. Drobegg, Brooklyn, N. Y.; Mr. E. Durant; Mr. Myron C. Durkee; Mrs. G. Durkyee; Dr. L. H. Duschak, Princeton, N. J.; Mr. T. A. Edison, Orange, N. J.; Dr. A. H. Elliott; Mr. H. H. Emrich, Maurer, N. J.; Mr. Charles Engelhard; Mr. H. Engle, Roanoke, Va.; Mr. Timothy P. Epps; Miss F. M. Eschenberg, Poughkeepsie, N. Y.; Mr. G. S. Ettla, Roanoke, Va.; Mr. Ernest Fahrig, Philadelphia, Pa.; Mr. J. M. Finch, New Rochelle, N. Y.; Dr. C. G. Fink, Schenectady, N. Y.; Mr. E. M. Fischer, Paris, France; Mr. C. M. Fitz Gerald; Mr. F. A. J. Fitz Gerald, Niagara Falls, N. Y.; Mr. R. Fleming, Lynn, Mass.; Mr. Alfred D. Flinn; Dr. R. von Foregger; Mrs. M. L. Foster; Mr. O. R. Foster, Brooklyn, N. Y.; Mr. C. F. Fowler; Dr. Franklin; Mr. Edward E. Free, Washington, D. C.; Miss E. M. Freeman, Poughkeepsie, N. Y.; Mr. R. H. Gaines; Mr. W. C. Geer, Akron, Ohio; Mr. W. U. Gillespie; Mrs. F. X. Gower, Oswego, N. Y.; Mr. F. Gowers, Oswego, N. Y.; Miss Mary Green; Mr. A. E. Greene, Heroult-on-the-Pit, Cal.; Mr. H. C. Griffin; Mr. A. E. Grip, Brooklyn, N. Y.; Mr. Geo. G. Grover, Ansonia, Conn.; Miss C. M. Guion, Poughkeepsie, N. Y.; Mr. Leo. F. Guttman; Dr. B. F. Halvorson, Kristiania, Norway; Miss H. Hamer, Manchester, England; Mr. W. J. Hammer; Mrs. J. Hampson, Ashton, England; Mr. William J. Hancock, Brooklyn, N. Y.; Mr. W. A. Harnor; Dr. E. I. Harrington, Yonkers, N. Y.; Mr. Martin Hedlund, Niagara Falls, N. Y.; Mr. F. C. R. Hemingway; Mr. and Mrs. C. I. B. Henning, Haskell, N. J.; Mr. Carl Hering, Philadelphia, Pa.; Mr. A. C. Higgins, Worcester, Mass.; Mr. W. E. Hilland, East Orange, N. J.; Dr. and Mrs. E. O. Hovey; Mr. and Mrs. Henry Howard, Brookline, Mass.; Mr. G. M. Howell, Philadelphia, Pa.; Dr. W. S. Howell; Miss A. C. Hughes; Dr. Geo. A. Hulett; Mr. W. R. Hulbert; Mr. W. F. Hurlbut; Mr. F. S. Hyde, Brooklyn, N. Y.; Mr. George Iles; Mr. and Mrs. W. R. Ingalls; Mr. and Mrs. Alois von Isakovics, Monticello, N. Y.; Mr. J. P. Irwin; Mr. H. A. Jackson, Wilmington, Del.; Mr. W. McA. Johnson, Hartford, Conn.; Mr. R. Compton Jones; Mr. C. M. Joyce, Arlington, N. J.; Dr. Edward Keller, Perth Amboy, N. J.; Mr. V. P. Krauss; Miss Bessie Kunz; Dr. and Mrs. George F. Kunz; Mr. G. H. Kunz; Mr. E. F. Lake; Mr. A. B. Lamb; Mr. I. Langmuir, Hoboken, N. J.; Mr. Arthur B. Larchar, Old Town, Maine; Mr. E. G. Lavino, Philadelphia, Pa.; Mr. E. J. Lavino, Philadelphia, Pa.; Mr. A. Lebrecht; Mr. T. Le Clear; Mr. W. G. Levison, Brooklyn, N. Y.; Dr. Morris Loeb; Mr. Horatio Loomis; Mr. A. V. Luther, South Orange, N. J.; Mr. Frank S. MacGregor, Hyde Park, Mass.; Mr. J. L. Mack, Nazareth, Pa.; Mr. Frederick Maeulen, Mount Vernon, N. Y.; Mr. C. O. Mailloux; Mr. H. T. Matthew; Mr. and Mrs. L. H. Maxim, Landing, N. J.; Mr. J. Y. McConnell, Colwyn, Pa.; Dr. Chas. F. McKenna; Mr. J. McLean, Brooklyn, N. Y.; Dr. W. McMurtrie; Mr. Sidney A. B. Meakin, Schenectady, N. Y.; Mr. Reginald Meeks; Mr. Bannista Merwin; Mr. John Meyer, Philadelphia, Pa.; Mr. H. S. Miner, Gloucester, N. J.; Mr. H. R. Moody; Mr. and Mrs. J. T. Morehead; Mr. Charles W. Moulton, Poughkeepsie, N. Y.; Mr. Charles J. Mullaly; Mr. C. I. Murphy, Haskell, N. J.; Mrs. Charles H. Naylor; Prof. E. F. Nichols; Dr. W. H. Nichols; Mr. C. Nielsen; Mr. S. I. Oestoneider, Newark, N. J.; Mr. Thos. F. O'Keeffe; Mr. J. W. Oman, Wilkesbarre, Pa.; Mr. J. R. O'Reilly; Mr. Brett Page, Bound Brook, N. J.; Mr. W. D. Pardoe, Princeton, N. J.; Prof. H. C. Parker; Dr. H. E. Patten, Washington, D. C.; Prof. C. E. Pellew; Mr. Herbert Philipp, Perth Amboy, N. J.; Mr. O. W. Pickering, Springfield, Mass.; Mr. J. Richmond Pitman, Orange, N. J.; Gen. John Pitman, Orange, N. J.; Mr. Y. Pitman, Orange, N. J.; Dr. Henry Noel Potter; Mr. E. W. Preston, Maywood, N. J.; Mr. A. S. Ramage, Detroit, Mich.; Mr. Charles L. Rand, Brooklyn, N. Y.; Mr. A. G. Reeve, Niagara Falls, N. Y.; Mr. John Rhodin, London, England; Prof. and Mrs. Joseph W. Richards, South Bethlehem, Pa.; Mr. F. Rigg, Palmerton, Pa.; Count and Countess Andre de Riva-Berni, Paris, France; Mr. H. Rodman, Pittsburg, Pa.; Dr. E. F. Roeber; Mr. A. J. Rossi; Mr. S. S. Sadtler, Philadelphia, Pa.; Mr. Pedro G. Salom, Philadelphia, Pa.; Mr. S. E. Sanders, Niagara Falls, N. Y.; Mr. M. F. Schack, Brooklyn, N. Y.; Dr. George P. Scholl; Mrs. Thomas Schoney; Dr. S. Schoney; Mr. F. F. Schuetz; Dr. and Mrs. F. A. Seeker, Hoboken, N. J.; Dr. Felig Seeler, Rahway, N. J.; Mr. George R. Seward; Dr. C. H. Sharp; Mr. Arthur Simmers, Perth Amboy, N. J.; Mr. and Mrs. Acheson Smith, Niagara Falls, N. Y.; Mr. E. W. Smith, Philadelphia, Pa.; Mr. and Mrs. W. H. Smith, Pittsburg, Pa.; Mr. F. G. Smull, Franklin Furnace, N. J.; Mr. E. A. Sperry; Mr. E. G. Sperry, Brooklyn, N. Y.; Mr. L. Sperry, Brooklyn, N. Y.; Prof. and Mrs. C. L. Speyers, New Brunswick, N. J.; Mr. J. Lorenz Sporer; Mr. Noel Statham, Mechanicville, N. Y.; Mr. H. I. Stevens; Miss L. S. Stevenson, Poughkeepsie, N. Y.; Mr. F. P. Stockbridge; Mr. G. C. Stone; Mr. Ernest Stütz; Mr. W. H. Swenarton; Prof. W. T. Taggart, Philadelphia, Pa.; Mr. and Mrs. E. R. Taylor, Pen Yan, N. Y.; Mr. Charles E. Taylor, Pen Yan, N. Y.; Mr. B. F. Thoman, Chattanooga, Tenn.; Dr. M. Toch; Mr. F. J. Tone, Niagara Falls, N. Y.; Mr. Philip Torchio; Prof. C. C. Trowbridge; Prof. Samuel A. Tucker; Mr. L. Vorce, Detroit, Mich.; Mr. J. C. Walker; Mr. D. W. Ward, Flushing, L. I.; Mr. John W. Ward; Mr. T. D. Waring, Perth Amboy, N. J.; Mr. W. D. Weaver; Mr. Utley Wedge, Ardmore, Pa.; Mr. J. G. Wells; Dr. E. Weston, Newark, N. J.; Miss Ruth Wheeler, Brooklyn, N. Y.; Mr. W. A. Whitaker, Jr.; Dr. W. R. Whitney, Schenectady, N. Y.; Dr. and Mrs. F. G. Wiechmann, Brooklyn, N. Y.; Mr. W. G. Wiechman; Mr. C. M. Williamson, Niagara Falls, N. Y.; Mr. and Mrs. Ernst Wollf; Mr. C. I. Zimmerman, Niagara Falls, N. Y.; Dr. F. Zimmerman, Newark, N. J.; Mr. Norman E. Zusi.

* * * *

At a meeting of the New York Section of the American Electrochemical Society last year, resolutions of sympathy on the occasion of the death of Prof. Henri Moissan were adopted, after an appropriate sketch of Moissan's life and work had been given by Dr. C. A. Doremus.

These resolutions of sympathy were forwarded by Mr. A. von Isakovics, as Secretary of the New York Section, to the Department of State in Washington, and were transmitted through the American Ambassador in Paris to the widow and son of Prof. Moissan.

In the following we give a translation of Mme. Moissan's letter in reply:

"To His Excellency, the Ambassador of the United States:

"In our great sorrow, allow me to say how much my son and myself are touched by the expression of sympathy that you have wished to transmit to us in the name of the American Electrochemical Society.

"While reading the message that your Excellency has conveyed to me, it brings to mind the pleasant and enjoyable hours that our dear departed one has spent in your fine country in 1896 and 1904.

"The welcome that he received then from his colleagues across the water greatly moved him—he used to speak of it often, and with pleasure express his admiration for the industry and the progressive spirit of the Americans.

"I beg therefore that your Excellency will convey our sincerest thanks to the American Electrochemical Society, and that it will accept our heartfelt appreciation.

(Signed) "L. Henri Moissan."

The Lash Steel Process and the Electric Furnace.

FROM THE FITZGERALD & BENNIE LABORATORIES.

In the numerous experiments that have been made with the object of producing steel direct from iron ore, one of the most serious problems was that of heating the furnace charge to the necessary temperature. In the blast furnace this is readily accomplished by mixing with the ore an excess of carbon, so that a part acts as reducing agent and a part as fuel, which gives the necessary heat by combustion in the blast. It is possible to make a mixture of ore and carbon where the latter is only present in the proportions necessary for reduction. to place this mixture in a suitable container and then to heat the latter by means of the combustion of fuel, so as to obtain an iron having the desired percentage of carbon; but such a process is not commercially feasible. In order to produce iron from the ore in a commercial manner it appears to be necessary to generate the heat in the charge itself.

The production of electric energy at a relatively low price and the consequent developments in the design of electric furnace led to the hope that the problem of the direct production of steel might be solved. Theoretically, it should be possible to place in an electric furnace a mixture of ore with only that amount of carbon necessary for reducing and for the proper carbon content in the metal to turn out the desired grade of steel. Experiment, however, has shown that this is not commercially feasible, because of technical difficulties which quickly appear when the attempt is made.

Successful experiments with the "Lash process" in the case of the open-hearth furnace on a commercial scale have indicated the possibility of its application to an electric furnace process.

In this process finely divided ore is intimately mixed with carbon, a certain quantity of finely divided carboniferous iron, such as cast iron borings or granulated pig iron, sawdust and fluxes suitable for the ore under treatment. The mixture is then ready for charging, either loose or in briquetted form, and in general it may be said that it must simply be heated to a sufficiently high temperature in order to obtain the steel.

The working of the process can perhaps be best explained by comparison with the open-hearth "ore process," which consists in first forming a bath of molten pig iron and then adding thereto a sufficient amount of ore (iron oxide) to reduce the carbon content of the metal to the desired amount. The oxygen of the ore combines with a certain amount of the carbon in the pig iron, forming carbon monoxide gas, and the iron of the ore is set free to mix with the bath of molten metal. Following this method we may work up together a mixture of approximately 75 per cent pig iron and 25 per cent ore. But in the Lash process these proportions are very different, for instead of treating a large excess of pig iron with a relatively small amount of ore, we can use a large proportion of ore with a smaller proportion of carboniferous iron.

Turning now to a more detailed examination of the Lash process, a typical mixture has the following percentage composition:

Iron ore	54
Cast iron borings or granulated pig iron	27
Sawdust	4
Limestone	4
Coal tar	3
Coke	8
	100

All the constituents of this composition are in a fine state of division intimately mixed, and when heated to a sufficiently high temperature the chemical reaction between the carbonaceous material and the ore proceeds readily, the iron oxide being reduced by the carbon, forming carbon monoxide gas and metallic iron. The function of the sawdust in the mixture is to make it porous, since at an early stage of the heating the sawdust carbonizes and leaves the mass in a porous state, permitting the easy escape of the gases formed during the reaction.

If we imagine the Lash mixture given above, heated to a high temperature, it is easy to see that the reactions which occur are similar to those found in the open-hearth furnace using the ore process. The cast iron borings correspond to the molten bath of pig iron and react with the ore, but the latter being in large excess it is necessary to supply a certain amount of free carbon in the form of coke, to supply sufficient carbon for the complete reduction of ore.

It is perfectly obvious where the great economy of the Lash process is found. since the proportion of ore to pig iron is very much greater than in the ordinary open-hearth process, where a large amount of pig iron and a relatively small amount of ore, or a mixture of pig iron and scrap, must be used. Put briefly, the Lash process is a method whereby a large amount of relatively cheap iron in the form of ore may be used to replace more expensive pig iron or scrap.

Now, in using the Lash mixture in the open-hearth furnace it is necessary to have a bath of molten metal, for were it to be charged into an empty open-hearth furnace it would not be practicable to heat it to the reacting temperature without losing carbon in the mixture by combustion. If, however, the charge is put into an electric furnace no difficulty of this kind is met with, since the gas in an electric furnace is neutral in contradistinction to the oxidizing atmosphere of an open-hearth furnace.

Experiments using the Lash mixture have been made in the electric furnace on a small scale, and the results have been very successful. In these experiments no bath of pig iron was used, but the mixture was heated alone in an electric furnace. It was found that the yield of metal amounted to 98 per cent of the metallic content of the mixture. Using electric energy as a source of heat is in general more expensive than heating by fuel, in spite of the fact that the heat generated is used much more efficiently in the electric than in fuel furnaces; but the economy in the electric furnace is found in the saving of pig iron, which must be used in the open-hearth process.

Thus, the average cost of the Lash process in the open-hearth furnace for Canada to produce 100 tons of ingots is as follows:

124 tons mixture	at $6.00	$755.16	60% metallic	74.4	tons.
32 " pig	at 22.00	704.00	95% "	30.4	"
2 " ore	at 5.00	10.00	60% "	1.20	"
½ " ferro	at 62.00	31.00			
			Total contents	106.00	"
Total cost charge		$1,500.16			
Credit 2 tons scrap at $18.00		36.00			
		$1,464.16			
Cost per ton				$14.64	
Cost conversion				4.00	
				$18.64	

If, on the other hand, the electric furnace is used, we would have the following figures:

174.7 tons mixture	at $6.09	$1,063.92	60% metallic	104.8	tons.
2 " ore	at 5.00	10.00	60% "	1.2	"
0.5 " ferro	at 62.00	31.00			
			Total contents	106.0	"
Total cost charge		$1,104.92			
Credit 2 tons scrap at $18.00		36.00			
		$1,068.92			
Cost per ton				$11.69	
Allowable cost of conversion in electric furnace to make total cost same as O.H. furnace				7.95	
				$18.64	

Now, the experimental work carried out in the electric furnace for the reduction of iron ore indicates that the cost of conversion should be as low or less than $7.95 per ton. and arrangements have therefore been made to test various electric furnaces, with the object of finding out those forms to which the Lash process is applicable.

Recapitulating, the electric furnace cannot be used at the

present time for the direct production of steel, owing to certain technical difficulties, but by applying the Lash process for the production of steel in the open-hearth furnace, with suitable modifications for the electric furnace, it is believed that the problem can be solved. Therefore, in all cases where for whatever reason the use of the electric rather than fuel furnace is desirable, steel may be produced directly from the ore in the former.

Oxygen in the Arts.

By Cecil Lightfoot.

Of the various factors which have hitherto militated against the more general application of oxygen in the arts and industries, the principal has, without doubt, been the impossibility of obtaining it in sufficiently large quantities at a sufficiently low cost. The rapid development which is taking place in the application of Dr. Carl von Linde's method of producing oxygen from the atmosphere by fractionation, offers good reason for the belief that a much more general use will be made of oxygen, particularly in metallurgical operations in the near future.

It is probable, however, that in most cases oxygen will not be employed in a state of purity, but will be used for the purpose of adding from 5 to 10 per cent to the quantity present in the normal air supply. In the case of a blast furnace the enrichment of the blast by the addition of 5 per cent of oxygen would have marked effects, which, so far as one can see should be distinctly beneficial. The first result would be to reduce the capacity of the blowing engines by 20 per cent. The absence of such a large volume of nitrogen would not only in all probability effect a considerable economy in the fuel consumption, but the furnace gases would have a much higher thermal value. It is conceivable that a plant to produce oxygen may, in the near future, become a necessary adjunct to the blast furnace. On such a scale the cost of the oxygen would be reduced to a very small amount.

In the same way it is highly probable that considerable economy would be introduced into other smelting operations by the use of oxygen, as, for instance, in the reduction of copper, and in the production of zinc, nickel and other metals. For the production of Bessemer steel the addition of a comparatively small quantity of oxygen during the first part of the blow would at once provide a means for reducing the time necessary for the operation. It would, in fact, seem that the process lends itself particularly to this application in view of the small amount of silicon in so much of the ore in this country.

German Bunsen Society.

The fourteenth annual meeting of the German Bunsen Society for Applied Chemistry was held in Hamburg, and a complete report of the proceedings is given in *Zeit. f. Elektrochemie*, June 28, July 5, 19, Aug. 9 and 16. The president, Prof. Walter Nernst, was in the chair. Geheimrat Dr. von Boettinger has granted a fund for a gold Bunsen medal to be granted every two years. The number of members is 702, among which are ten honorary members and twelve life members. The next annual meeting will be held in Vienna.

Radioactivity and Disintegration of Atoms.—A symposium of papers on this subject was the program of the first session. All these papers may be found in *Zeit. f. Elektrochemie*, July 5. Prof. Voller gave an introductory sketch of radioactivity. He concisely reviewed the investigations on electric discharges through rarified gases, and especially on the phenomena of cathode rays, which have led to the conceptions of negative corpuscles or electrons in the cathode rays and of positive ions in the anode radiation; on the other hand, Roentgen rays carry no measurable charges. Then came the detection of radioactive substances and the discovery of three kinds of radiations from them: alpha rays with positive charges, beta rays with negative charges, and gamma rays without charges. For discharges through rarified gases the conclusion was reached that we have to do with a disintegration of atoms which give off electrons. On account of the analogy sketched above the question arises whether we also have to do with disintegration of atoms in the phenomena of radioactivity. The tendency is now to give an affirmative answer to this question.

Prof. W. Marckwald spoke of the chemical behavior of radioactive substances. We have to assume now some twenty new radioactive elements. Most of them are known only from their radiating ability and characterized by their constants of decay. The author sketched the methods of winning radium from pitch-blende, the electrolytic separation of polonium from bismuth in pitch-blende, the chemical properties of actinium and of the so-called emanations (apparently inert gases of the argon type). The separation of the radioactive disintegration products of the emanation is partly possible by electrolysis, for instance, the separation of thorium A from thorium B.

Prof. G. Meyer spoke on the production of helium from radioactive substances. Ramsay and Soddy found in 1903 by spectroscopic methods that helium is formed from radium. Other investigators confirmed this experimental result. The objection has been raised that the helium observed in the spectral tubes was gas occluded in the radioactive substances and taken over in their preparation from the uranium ore. More recent experiments by F. Himsted and G. Meyer show that this explanation is not valid. It is a fact that salts of radium and actinium produce helium, that this is not gas taken over from the uranium ore, and that its fixation in the radioactive substances is different from occlusion or chemical combination of gases. According to Rutherford's hypothesis, helium is formed from the alpha particles. All disintegration products of radium, which give off alpha rays, should therefore produce helium.

Dr. F. Von Lerch spoke on the nature of radiactive radiation. The alpha, beta and gamma rays behave differently with respect to deflection by magnetic and electric force (from which the speed and the ratio of charge to mass may be determined), with respect to penetration through different materials, and with respect to the ionization which they produce. As to the deflection by magnetic and electric forces, alpha rays are slightly deflected in a direction indicating that they carry a positive charge. Beta rays are strongly deflected in a direction indicating that they are negatively charged. Gamma rays are not deflected. As to absorption, alpha rays are absorbed by mica or aluminium plates 0.1 mm. thick; beta rays are absorbed by aluminium 5 mm. thick, or by lead 2 mm. thick; gamma rays pass even through 300 mm. thick iron. The ionizations produced by alpha, beta and gamma rays, respectively, are roughly in the relation of 10,000 to 100 to 1.

The gamma rays from radium are not homogeneous; only the rest which is left after the rays have passed through thick lead plates has a constant coefficient of absorption. The gamma rays only occur together with beta rays. Gamma rays are apparently produced at places where beta rays are absorbed.

The beta rays have a velocity between one-fifth and nine-tenths of the velocity of light. The ratio of charge to mass for a corpuscle is not constant, but decreases with the speed. For the lowest speeds the ratio gets approximately that of cathode rays, so that the radiated particles or corpuscles may be assumed to be the same in both cases. The mass of such a particle is about one-two thousandth of the mass of a hydrogen atom. The beta rays of radium and thorium are not homogeneous.

For the alpha particles the ratio of charge to mass is 0.507×10^4, and this value is the same for the alpha particles radiated from any substance. The alpha particles resulting from the different evolution products of radium and from radium itself

are identical with those from actinium and those from thorium. The ratio of charge to mass for the electrolytic hydrogen ion is 10^4, hence twice the ratio of the charge to mass of the alpha particle. Since the assumption is now made that the helium produced from radioactive substances consists of alpha particles, and since the atomic weight of helium is 4, two hypotheses are possible. Eeither the alpha particle is one-half helium atom with the charge of the hydrogen ion, or the alpha particle consists of a whole helium atom charged with two elementary electric charges.

Alpha particles emitted from different substances differ only with respect to their speed (not with respect to the ratio of charge to mass). For a homogeneous radioactive substance the speed with which all particles are emitted is the same, and the initial speed is a characteristic constant of the substance. The alpha particles ionize the air only within a certain distance; this is a constant which may be easily determined. At the same distance the alpha particles lose their photographic activity and their effect on a phosphorescent screen.

Dr. OTTO HAHN discussed Rutherford and Soddy's hypothesis of the disintegration of atoms. He sketched the experimental work on which it is based, and gave a graphical table showing the evolution due to atomic disintegration, of uranium, sodium, actinium and thorium. For radium, for instance, we have: Ra, giving off alpha rays, forms (2,600 years) Em, which giving alpha rays, forms (3.8 days) RaA, which giving off alpha rays, forms (3 minutes) RaB, which giving off beta rays, forms (26 minutes) RaC, which giving off alpha rays and beta and gamma rays, forms (19 minutes) RaD, which forms (about forty years?) RaE_1, which forms (6 days) RaE_2, which giving off beta rays forms (4.8 days) RaF, which is nothing else but the polonium of Mrs. Curie and the radiotellurium of Marckwald. This disintegrates (143 days) forming probably ordinary lead.

The figures given above in parentheses represent the time in which the activity decreases to one-half its original value. For instance, the activity of any sample of radium decreases to one-half in 2,600 years. From 1 gram of radium there would be left as radium proper only ½ gram. The other half would partly have escaped as helium, but the greater part would be in form of an inactive final disintegration product mixed with radium.

In the discussion, Prof. LANDOLT referred to the very extended researches which he has made to test by weighing the constancy of mass in chemical reactions. While he had found in all cases a very slight diminution of weight, he has now traced this to a source of error, namely, the slowness with which the glass vessels return to their original volume from the increased volume due to heat. "The question whether the law of the conservation of mass when tested experimentally has perhaps been found to be not absolutely correct, has now been answered in the negative."

Dr. M. LEVIN discussed some consequences of the hypothesis of atomic disintegration, especially the age of minerals and the part which radium plays in the heat economy of the earth and the sun. Prof. F. HENRICH discussed the radioactivity of air and spring waters.

Finally, a general discussion was held. Prof. TAMMANN brought up the question whether the "radioactive elements" are really elements. Prof. Nernst thought this to be simply a matter of definition, but Tammann did not think so; the latter also raised the question, where to place the radioactive elements in the periodic system. Dr. Hahn replied that Rutherford always emphasizes that the quickly disintegrating radioactive products should not be expected to fill gaps in the periodic system. The periodic system appears to represent elements with a certain stability. Prof. Brauer brought up the other question, why there exist gaps in the periodic system, especially in the highest regions. "Why have we no more element after bismuth (208) until radium? Then there is another gap till thorium, then comes uranium, and that is all I believe that may be explained by the following hypothesis, though I can't prove it. I assume that there are dead, extinct elements which exist no longer, but have been disintegrated. Why not? Why should there be no elements of short life?" Prof. Nernst seemed to feel somewhat dejected by this idea and offered the more joyful hypothesis that some elements have not yet been borne.

Atomic Weights.—One of two papers dealing with this subject was presented by Prof. B. BRAUNER (*Zeit. f. Elektrochemie*, July 19). He spoke in the most complimentary terms of the classical researches of Theodore W. Richards, of Harvard, and then criticized the table of atomic weights of the International Committee. The new values of Richards should be adopted, and the committee should not avoid the trouble of revising the whole table if this becomes necessary as the result of modern researches.

Dr. A. L. BERNOULLI presented a paper (*Zeit. f. Elektrochemie*, Aug. 16) in which he gave on the basis of thermodynamics a recursion formula of atomic weights. It is essentially a development of Lockyer's idea that the series of the atomic weights of the stable conditions of hydrogen represents the series of atomic weights of all imaginable chemical elements. The series calculated by the author agrees remarkably well with actual values.

Compressibility of Elements.—Prof. TH. W. RICHARDS (Harvard) described a differential apparatus devised by him for determining the compressibility of substances, and gave the results of the determination of the compressibilities of thirty-five elements. The values vary greatly for different substances. Thus silicon, which is probably the least compressible element, has a compressibility of 0.00000016, while the value for chlorine is, for instance, 0.00009. The values of the compressibility are a periodic function of the atomic weights. The paper may be found in *Zeit. f. Elektrochemie*, Aug. 9. while the full account of the investigation has been issued as No. 76 of the publications of the Carnegie Institute, of Washington.

Fused Salts.—A paper by Dr. K. ARNDT (*Zeit. f. Elektrochemie*, Aug. 9) gave the results of some measurements of the conductivity of fused salts. Of special interests are the tests of a fused mixture of a salt of good conductivity and a non-conductor, namely, a solution of fused $NaPO_3$ (conductor) in fused B_2O_3 (practically a non-conductor) at 900° C. The equivalent conductivity decreases much more rapidly than the concentration; simultaneously, the tenacity increases with decreasing concentration. The product of equivalent conductivity and tenacity is constant. "The decrease of equivalent conductivity may therefore be thought to be due to the increase of internal friction of the solution; it follows that the degree of dissociation of the dissolved fused salt does not vary with dilution. This phenomenon may be explained in the simplest way by the assumption that the fused sodium metaphosphate is completely ionized." A second paper of the author on the measurement of tenacity at high temperatures may be found in *Zeit. f. Elektrochemie*, Aug. 23.

Synthesis of Ammonia.—A paper by Prof. W. NERNST (*Zeit. f. Elektrochemie*, Aug. 9) dealt with the equilibrium of the reversible reaction $2NH_3 = 3H_2 + N_2$. A thermodynamical theory of Nernst on chemical equilibria had been found, in this single case, to be in poor agreement with the results of measurements. For a partial pressure 0.00012 of ammonia, formed at atmospheric pressure, Nernst's theory had given the absolute temperature 893, while Haber and van Oordt had found experimentally 1,293. From recent measurements of Nernst and Jost it appears that the former poor disagreement was due to sources of error in the former experimental method. At the high temperatures at which Haber had to work on account of the low speed of formation of ammonia from nitrogen and hydrogen, he got only a very small yield. According to the law of mass action this yield may be increased by increasing

the pressure. For this reason Nernst and Jost employed a small electric furnace, in which the reaction between the gases was brought about at a high pressure and at strictly defined temperatures. The agreement between experiment and theory is now much better. The new figures show, however, that the synthesis of ammonia from nitrogen and hydrogen is by no means as promising a problem as had formerly been thought.

Effect of Light on the Formation of Sulphuric Acid.—A paper by Prof. Coehn described experiments showing that light from a quartz arc lamp strongly accelerates the reaction $3SO_2 = 2SO_3 + S$, and also the reaction $2SO_2 + O_2 = 2SO_3$. For both reactions it is essential that the reaction gases have not been dried beyond a certain degree of humidity. If we have to do here with a displacement of the equilibrium, due to light, it must be possible to reach the equilibrium also from the other side. Indeed, it was found that SO_3, under the influence of light, was dissociated into O_2 and SO_2, and that the equilibrium which was reached in this way was about the same as when it was reached from the other side. In both cases it seems that the ultra-violet rays are those which are specially active.

The action of the light is, however, not the same in the formation and in the dissociation of SO_3. In the formation of SO_3, that is, in the reaction of $2SO_2 + O_2 = 2SO_3$, the light acts like a catalytic agent, while in the dissociation of SO_3, that is, in the reaction $2SO_3 = 2SO_2 + O_2$ the light performs work. From this it follows that the stronger the light the greater is the dissociation of SO_3 in the condition of equilibrium. Hence, if we want to form SO_3 from SO_2 and O_2, the gas mixture in state of equilibrium will contain a smaller percentage of SO_2 the stronger the light effect. This apparent paradox was confirmed experimentally by operating the quartz arc lamp at 6 and 9 amps.

A paper by Dr. Trautz (*Zeit. f. Elektrochemie*, Aug. 16) dealt with some special cases of the influence of variation of temperature on the speed of reaction in photochemical reactions.

Influence of Temperature on Metal Deposition.—Prof. F. Foerster's paper on this subject (*Zeit. f. Elektrochemie*, Aug. 16) first referred to the well-known effect of improving the solidity of metallic deposits (for instance, nickel) by an increase in temperature. This is due to increased diffusion and stronger circulation, as a result of which fresh metal ions are continually brought right to the cathode surface on which they are to be deposited. However, the present paper shows that an increase of temperature may also have in special cases an essentially different effect, namely, a decrease of the "reaction resistances" which render metallic deposition difficult. For instance, for the deposition of copper from a cyanide solution the required voltage increases considerably, with increasing current density, at 18° C., while the corresponding increase of the required voltage is very much less at higher temperatures. An increase in temperature may change in such cases the position of the metal in the "nobility" series, for instance, compared with hydrogen. Prof. Foerster showed that this principle permits interesting applications to the separation of different metals.

Miscellaneous Papers.—The balance of the papers presented at the meeting dealt with the following subjects: Prof. R. Luther, on electrochemical "activity phenomena" (with reference to vanadic acid in electrolysis); Prof. R. Abegg, on two new potentials $NO_3' \rightarrow NO_2$ (1.2 volts), and $Au' \rightarrow Au$ (1.46 volts); Dr. W. Guertler, on the electric resistance of metallic alloys, with special reference to the occurrence of alloy crystals; Prof. Karl Scheel, on the determination of the coefficients of refraction of gases at ordinary temperature and at the temperature of liquid air; Prof. Emil Bose, on the physical properties of emulsions, especially on their relation to the crystalline liquids; Prof. F. Haber, on the gas refractometer, *i. e.*, on determination of density by measurement of the coefficient of refraction (all these papers being published in *Zeit. f. Elektrochemie*, July 19); further, Prof. Walther Loeb, on the chemical theory of alcoholic fermentation; Dr. Jordis, on further researches on silicates, a contribution to the chemistry of colloids; Dr. H. Bechhold, on studies of colloids by the filtration method; Dr. R. O. Herzog, on diffusion of colloids (all these papers being published in *Zeit. f. Elektrochemie*, Aug. 9); further, Dr. E. Abel, on intermediary reactions in catalysis, and Dr. Max Von Vogau, on diffusion of metals in mercury (*Zeit. f. Elektrochemie*, Aug. 16).

Metallurgical Calculations.

By Jos. W. Richards, Ph. D.,
Professor of Metallurgy in Lehigh University.

(*Continued from page 405.*)

I. 4. Electrolytic Refining of Impure Copper.

This subject is a large one. It lends itself very well to calculation. It is also comparatively simple in principle. Given a nearly pure copper plate or slab as an anode, in a solution of a copper salt, and a suitable conducting cathode, the metal is simply dissolved and deposited, or is "plated over." The process really consists in extracting copper from the solution at the cathode, and sending it and other soluble impurities into the solution at the anode. The mechanical transportation of the copper, in space, through a distance equal to the space between anode and cathode, is sometimes emphasized as the chief mechanical work done. It is a real fact that the metal is taken out of the solution at a different spot from where it goes in, but the electric current does not do that transportation—diffusion and circulation are the agents which transport the copper entering the electrolyte at the surface of the anode plate to the surface of the cathode plate, and electric energy does nothing more than create the differences of concentration, which are thus physically neutralized.

The chief expenditure of electrical energy in the refining bath is that converted into sensible heat in overcoming the ohmic resistance of the electrolyte. The other items of electrical work are the overcoming of the ohmic resistance of hangers, rods, bus-bars, clamps and connectors, and the not unimportant resistance of contacts; also the difference of chemical work done in depositing all copper and dissolving part copper and part other impurities; also the chemical work of separating the ingredients of the impure copper, which may be alloyed and have some heat of combination which must be furnished by the current in order to separate them.

Energy Absorbed by the Electrolyte.

The electrolyte is a conductor and absorbs energy according to Ohm's law whenever current passes through it. The solution used in copper refining is almost invariably copper sulphate acidulated with sulphuric acid. The resistivity of copper sulphate, iron sulphate and sulphuric acid solutions, at 20° C., is as follows, in ohms per centimeter cube and ohms per inch cube:

Per Cent.	*$CuSO^4$.*		*$FeSO^4$.*		*H^2SO^4.*	
in	Ω *per*	Ω *per*	Ω *per*	Ω *per*	Ω *per*	Ω *per*
Solution.	*cm.³*	*inch³.*	*cm.³*	*inch³.*	*cm.³*	*inch³.*
2.5	92	37	..	..	....	....
5.	53	21	..	..	4.8	1.9
7.5	..	..	65	26	....	....
10.	31	12	..	..	2.5	1.0
15.	24	10	34	14	1.8	0.7
17.5	22	9	..	..	....	....
20.	..	..	..	..	1.5	0.6
25.	..	..	..	..	1.4	0.56
30.	..	..	25	10	1.37	0.55

The plain copper sulphate solution is thus seen to be a rather

poor conductor; iron sulphate is not so good; sulphuric acid is highly conducting. It is therefore evident that the ohmic resistance of the bath is, for practical purposes, dependent upon its content in free acid; hence the great economic importance of keeping the bath well acidulated. As the bath grows foul with iron sulphate and loses sulphuric acid by formation of insoluble sulphates, chemical solution of slimes, etc., the bath becomes poorer conducting and the energy absorbed in it much greater. A solution in good condition, with 15 to 20 per cent of $CuSO^4$ and 5 to 10 per cent free H^2SO^4, may have a resistivity of only 2 to 5 ohms at starting, which may increase to 20 or 25 ohms as the solution becomes impure and the free acid disappears. These facts are of immense importance in the economics of refining.

A comprehensive, systematic study of the resistivities of solutions of various strengths of copper sulphate with various percentages of iron sulphate present and various content of sulphuric acid is greatly needed, and would not be a difficult research to carry out. One of the writer's electrometallurgical students is at present engaged on this work.

Problem 118.

A refining bath is run with a current density of 250 amperes per square meter, with electrodes 4 c.m. apart, and starting with electrolyte 15 per cent $CuSO^4$ and 10 per cent H^2SO^4. It is run until the sulphuric acid has decreased to 5 per cent.

Required:

(1) The probable voltage drop across the electrodes at starting.

(2) The same when the second condition is reached.

(3) The rate at which the solution would start to rise in temperature at the beginning, ignoring the electrodes.

(4) The rate, assuming anodes 5 c.m. thick and copper cathodes 0.5 c. m. thick.

Solution:

(1) Lacking the experimentally determined datum of the resistivity of the primary solution, we know that it will be somewhere about that of the 10 per cent sulphuric acid solution, viz.: 2.5 ohms. It should be slightly less, because of the copper salt present, and if we assume the conductivity of the solutions as additive, we would have a conductivity of the mixed solution, in reciprocal ohms as

$$C = \frac{1}{2.5} + \frac{1}{24} = 0.40 + 0.04 = 0.44$$

$$R_{sp.} = \frac{1}{0.44} = 2.3 \text{ ohms.}$$

Using this resistivity, the voltage drop across the electrodes, at starting, will be

$$V^e = 2.3 \times 4 \times 0.0250 = \mathbf{0.23} \text{ volts.} \qquad (1)$$

(0.0250 amperes goes across each square centimeter and the plates are 4 centimeters apart.)

(2) With H^2SO^4 only 5 per cent, and copper contents, say, 20 per cent, because of solution of copper by free acid, we would have

$$C = \frac{1}{4.8} + \frac{1}{20} = 0.1 + 0.05 = 0.26$$

$$R_{sp.} = \frac{1}{0.26} = 3.6 \text{ ohms.}$$

Using this resistivity, the voltage drop is

$$V^e = 3.6 \times 4 \times 0.0250 = \mathbf{0.36} \text{ volts.} \qquad (2)$$

In actual practice an increase of 0.01 volt above this might be expected, because of the formation of a film of slime on the surface of the anode.

(3) The solution at starting has a specific gravity of 1.20 and a specific heat of 0.875. (Combination of data from Laudolt-Bornstein-Meyerhoffer's Tabellen.) The water value as heat absorber of a column of liquid 1 c.m.^{3} and 4 c.m. long, between the electrodes, is therefore

$$1.2 \times 4 \times 0.875 = 4.2 \text{ calories per } 1^\circ \text{ C.}$$

Heat equivalent of the electric energy expended

$$0.23 \times 0.0250 \times 0.2389 = 0.00138 \text{ calories per } 1''.$$

Rate of rise of temperature of solution

$$0.00138 \div 4.2 = 0.00032^\circ \text{ per second}$$
$$= 0.0198^\circ \text{ " minute}$$
$$= \mathbf{1.2^\circ} \text{ " hour} \qquad (3)$$
$$= \mathbf{28.8^\circ} \text{ " day}$$

(4) With half the thickness of anode and cathode to be supplied with heat, the copper having a specific gravity of 8.9 and specific heat of 0.093, the water value of the copper concerned per square centimeter area of electrolyte section is

$$\left(\frac{5.0}{2} + \frac{0.5}{2}\right) \times 8.9 \times .093 = 2.276 \text{ calories per } 1^\circ.$$

Rate of rise of temperature of solution plus electrodes:

$$0.00138 \div (2.276 + 4.2) = 0.00021^\circ \text{ per second}$$
$$= 0.013^\circ \text{ " minute}$$
$$= 0.78^\circ \text{ " hour}$$
$$= \mathbf{18.7^\circ} \text{ " day} \qquad (4($$

Energy Lost in Contacts.

This is an extremely variable and yet important factor in the economics of copper refining. No one item in copper refining will at the present time better repay close attention and study of methods of improvement. A proper contact should cause a very small voltage drop to begin with, and should be capable of being kept efficient—that is the chief requirement. Contacts are often made on the hit or miss style, and arranged in such position as to receive spattering or drippings from the electrolyte; such may cause immense losses of electrical energy as they rapidly pass from bad to worse.

B. Magnus (ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, December, 1903), and L. Addicks (*idem.*, January, 1904) have given us valuable information on this point. The weight of the plates, when resting on the contacts, improves the contact; in such cases the anode contacts are best when the tank is first set up and the cathode contacts worst. In such cases a screw clamp, to put several hundred pounds of mechanically applied pressure on the joint, should be adopted, so as to make the contacts "best" all the time.

Figures given by Magnus as a carefully determined average of results in a Western refinery are:

Current	4,000 amperes			
Current density (per sq. ft.)	11 "			
Total voltage per tank	0.230 volts			
Energy used per tank	0.920 kw.			
				Per Cent.
Drop, bus bar to anode rod	0.0270 volts			
" anode rod to anode hanger	0.0060 "			
" anode hook to anode	0.0008 "	= 0.0338 =		14.7
" anode to cathode	0.1782 "	= 0.1782 =		77.5
" cathode to cathode rod	0.0045 "			
" cathode rod to bus bar	0.0135 "	= 0.0180 =		7.8
		0.2300		100.0

It thus appears that in this tank the loss in contacts was some 20 per cent of the total voltage employed (assuming the anode rods to be of such design that their resistance was negligible). Magnus fitted up a similar tank with mercury cup contacts, and found a drop from bus-bar to anode rod of 0.0050 volt instead of 0.0270, and cathode rod to bus-bar 0.0050 instead of 0.0135 volt. If it were possible in the case of above tank to make these improvements alone, the saving on voltage per tank would be 0.0305 volt, or 13.3 per cent of the voltage used, which means a saving of 13.3 per cent of the power required to run the tank.

Problem 119.

In an electrolytic refinery system of 200 tanks the resistance of the contacts was, on an average, 0.0368 volt per tank, and 0.2567 volt across two electrodes; 3,800 amperes was passed through the series, and the voltage at the terminals of the dynamo was 67 volts. Power costs $157 per kilowatt-year. Efficiency of deposition of copper 82 per cent.

Required:

(1) The cost of power per ton (2,000 pounds) of copper refined.

(2) The cost per ton of copper produced of the power lost by (a) resistance of the conductor bars (b) by the contacts, and (c) consumed in the electrolyte itself.

(3) If interest on capital is 6 per cent, what expenditure would be justified on means for (a) reducing the conductor losses (b), reducing the contact losses (c), reducing the electrolyte losses?

(4) If the ampere efficiency of deposition could be increased 5 per cent by reducing the current density 20 per cent, would it pay?

Solution:

(1) Copper deposited in 1 tank per day

$3800 \times 0.82 = 3118$ oz. = 195 lbs.

In 200 tanks

$200 \times 195 =$ 39,000 "

Power used

$3800 \times 67 \div 1000 =$ 255 kw.

Cost of power per day

$255 \times \$157 \div 365 =$ $109.70

Cost of power per 2,000 lbs. copper

$\$109.70 \div 19.5 =$ **$5.63** (1)

(2) The voltage lost in the conductors is

$67 - 200(0.0368 + 0.2567) = 67 - 58.7 =$ 8.3 volts

and the power thus lost

$3800 \times 8.3 \div 1000 =$ 31.54 kw.

Cost per year $31.54 \times 157 =$ $4,952.00

Cost per day $4952 \div 365 =$ $13.57

Cost per ton of copper produced = **$0.70** (2a)

Power lost in the contacts

$200 \times 0.0368 \times 3800 \div 1000 =$ 27.97 kw.

Cost, per year = $4,391.00

Cost, per day = $12.03

Cost, per ton = **$0.62** (2b)

Power consumed in the electrolyte

$200 \times 0.2567 \times 3800 \div 1000 =$ 195 kw.

Cost, per year = $30,615.00

Cost, per day = $83.88

Cost, per ton = **$4.30** (3b)

(3) The cost of the power lost per year, divided by 0.06, will give the capital investment representing that yearly outlay. This would be

	Cost of Power.	*Capitalized.*
Conductor resistances.....	$4,952	$82,530
Contact resistances.....	4,391	73,180
Electrolyte resistances.....	30,615	510,250

In the specific cases in point each 1 per cent of the power consumption which could be saved by improvements of a permanent character, not subject to depreciation, would justify capital expenditures in the plant up to the following amounts:

Conductor resistances.....	$825
Contact resistances.....	732
Electrolyte resistances.....	5,100

If the improvements were liable to depreciation in use, such as larger tanks, contact clamps, etc., the depreciation must be added to the interest to find the justifiable capital expenditure. Assuming depreciation 10 and 20 per cent, respectively, this plus interest amounts to 16 and 26 per cent, and the justified expenditures must be less than the following amounts for 1 per cent saving of power in each direction:

	10% *Depreciation.*	20% *Depreciation.*
Conductor resi tances.....	$309.50	$190.50
Contact resistances.....	274.50	169.00
Electrolyte resistances.....	1,913.50	736.00

There is here a wide field for experiment and improvement. In the case in point, making all allowances, one would be justified in expending in permanent plant for each tank at least $1.00 for every 1 per cent reduction which could be made in the power loss in the conductors, $0.85 for every 1 per cent gained in reducing contact resistances and $3.68 for each 1 per cent reduction in the resistance of the electrolyte. To be more specific, assume the main conductors to be proportioned to carry 2,000 amperes per square inch of cross-section. Their resistance in the case in point is $8.3 \div 3,800 = 0.0022$ ohm, cross-section 1.9 square inches, resistance per running inch $0.00000067 \div 1.9 = 0.00000035$ ohm, and total length $0.0022 \div 0.00000035 = 6,286$ inches $= 524$ feet.

The weight, at $62.5 \times 8.9 \div 1,728 = 0.322$ lbs. per cubic inch is

$6,286 \times 1.9 \times 0.322 = 3,846$ lbs.

which at $0.20 per lb. costs

$\$3,846 \times 0.20 = \$769.20$

Since there is practically no depreciation (except change in market value) in these copper conductors, if we increased the cross-section of the conductors 100, 200, 300, 400 per cent, respectively, we would decrease their resistance 50, 67, 75 and 80 per cent, respectively, and arrive at the following figures:

		Per Ton of Copper Produced.			
Per Cent. Increased Size of Conductors.	*Per Cent. Decreased Resistance of Conductors.*	*Increased Cost of Plant.*	*Interest on Increased Cost of Plant.*	*Decreased Cost of Power.*	*Gain.*
100	50	$769	$0.0065	$0.35	$0.35
200	67	1,538	0.013	0.47	0.46
300	75	2,307	0.019	0.52	0.50
400	80	3,077	0.026	0.56	0.53
900	90	6,923	0.058	0.63	0.57
1,900	95	14,613	0.123	0.67	0.54

We thus see that for this plant, with power costing $157 a kilowatt-year and copper bar $0.20 per pound, a great reduction in the power costs up to $0.57 per ton of copper produced can be made by making the main conductors *ten times* as large; that is, by making them carry only 200 amperes per square inch of section instead of 2,000.

At a locality like Great Falls, Montana, where the water power does not cost over one-tenth the above price, let us say $15.70 per kilowatt-year, the decreased cost of power, in the above table would be one-tenth the above figures—there would be only $0.07 per ton of copper to save if all were saved, and it can easily be seen that the gains would be

for	100	per cent.	increased	size.....	$0.029
"	200	"	"	"	0.034
"	300	"	"	"	0.033
"	400	"	"	"	0.030

We reach the maximum saving in this case by increasing the size 200 per cent, giving a current density of 660 amperes per square inch of conductor section.

It can easily be seen that the cost of copper bars, rate of interest, and cost of power are all three factors in determining the economic size to be given the conductors. In general they are made much smaller than they should be because of lack of capital to invest in them. As soon as a refinery is running and paying dividends part of its profits should be ap-

plied to permanent investment in heavier copper conductors in order to reduce the running costs.

(4) If the ampere efficiency were increased 5 per cent and the current density 20 per cent, all other data being constant except those affected by these changes, the output of copper would be 87 per cent of the theoretical output of 3,040 amperes instead of 82 per cent of the theoretical output of 3,800 amperes. The output of copper per day would therefore be, in place of 39,000 pounds:

$$3{,}040 \times 0.87 \times 200 \div 16 = 33{,}060 \text{ lbs. per day.}$$

The power cost will be reduced 20 per cent by the lower amperage used, that is, be $\$5.63 \times 0.80 = \$4.50$ per ton—a saving of $1.13. Whether it will pay to do this depends of what the other fixed charges of the plant are. Decreasing the output 15 per cent increases the fixed charges per ton of copper produced 12 per cent. It is then a question whether 12 per cent of the fixed charges in the first case is greater or less than $1.13. If the fixed charges amounted to, say, a usual figure of $5.00 per ton, decreasing the output 15 per cent. would increase this charge per ton of copper produced 12 per cent, or $0.60; but if there is a power saving of $1.13 there is a margin of $0.53 per ton in favor of making the change. If the power cost were only $0.56 per ton of copper it would just barely pay to make the change. Everything depends upon the relative cost of power and of the other fixed charges.

Energy Lost in Conductors.

We have already touched on this subject, but it deserves still greater attention. The resistivity of copper is 0.00000167 ohm per centimeter cube, or 0.00000067 ohm per inch cube. Given a conductor of certain length its resistance in ohms is 0.00000167 multiplied by its length in centimeters and divided by its cross sectional area in square centimeters. The similar calculation can be made for the inch units. The drop in potential in the bus-bars is their resistance multiplied by the amperes passing, and the power consumption is the voltage drop into the amperes passing or the resistance in ohms into the square of the amperes passing. The watts thus expended may be expressed in kilowatts, or transposed into horse-power by dividing by 746. The heat generated in the conductors is, per second, in gram calories, the number of watts expended in them multiplied by 0.2389. The rate of rise of temperature of the conductors, leaving out radiation and conduction to the air, will be, per second, the gram calories generated in the conductors divided by the heat capacity of the conductors per degree, which in the case of copper is volume in cubic centimeters into 0.837. This rise in temperature will continue until by radiation and conduction to the air the conductors lose as much heat per second as the current generates in them. This will vary with the shape of the cross section of the conductors, because the loss of heat is proportional to the surface exposed, and the area of exposed surface for a given cross section is greater the thinner the conductor and is a minimum for a round conductor. The amount of heat thus lost can be calculated by the principles explained in Metallurgical Calculations, Part I., pp. 172-186. If it is desired to get along with the minimum heating of the conductors, they should be as flat and thin as possible; if heating can be ignored they may be of the cheap round shape. It should not be forgotten also that the resistivity of copper increases as it gets hotter in direct proportion to its absolute temperature ($C° + 273$), so that the heating effect really aggravates itself from this increased resistance.

Problem 120.

A copper conductor is desired to carry 4,000 amperes, 300 meters. Round bars sell at 18 cents per pound. Interest rate 10 per cent. Cost of electric power as delivered $50 per kilowatt year. Average temperature of surrounding air 20° C, air still. Conductivity of the copper 600,000 reciprocal ohms per centimeter cube. Specific gravity of copper 8.9, specific heat 0.094.

Aluminium conductors to replace same have conductivity of 375,000 reciprocal ohms, specific gravity 2.60, specific heat 0.230; cost of round bars 36 cents per pound.

Required:

(1) The cross-sectional area of the conductors of copper which will give the minimum cost of power and interest on the investment.

(2) The same for aluminium.

(3) The running temperature of the conductors of copper above the room temperature.

(4) The same for aluminium.

Solution:

(1) Let S = cross section of conductor, in sq. cm.

Resistance of copper conductor

$$0.00000167 \times (300 \times 100) \div S = \frac{0.0501}{S} \text{ ohm.}$$

Power expended in the conductor:

$$\frac{0.0501}{S} \times (4{,}000)^2 = \frac{801{,}600}{S} \text{ watts.}$$

Cost of power thus expended, per year

$$\frac{801{,}600}{S} \div 1{,}000 \times 50 = \frac{40{,}080}{S} \text{ dollars.}$$

Weight of copper in conductor:

$$(300 \times 100) \times S \times 8.9 \div 1{,}000 = 267.\ S. \text{ kilograms.}$$

Cost of conductor, if round

$$267.\ S \times 0.18 \times 2.205 = 106.\ S. \text{ dollars.}$$

Interest on cost of conductor, at 10% $= 10.6 \times S$ dollars.

Sum of cost of power and interest on investment:

$$\frac{40{,}080}{S} + (10.6 \times S)$$

Solving for S a minimum, we find $S = 61.5$ sq. cm. (1)

Total costs, substituting S above

$652 (for power) + $652 (interest) = $1,304 per year.

(2) Resistance of aluminium conductor

$$0.00000267 \times (300 \times 100) \div S = \frac{0.0801}{S} \text{ ohm.}$$

Power expended in the conductor

$$\frac{0.0801}{S} \times (4{,}000)^2 = \frac{1{,}281{,}600}{S} \text{ watts.}$$

Cost of power thus expended, per year

$$\frac{1{,}281{,}600}{S} \div 1{,}000 \times 50 = \frac{64{,}080}{S} \text{ dollars.}$$

Weight of aluminium in conductor

$$(300 \times 100) \times S \times 2.6 \div 1{,}000 = 78.\ S. \text{ kilograms.}$$

Cost of conductor, if round

$$78.\ S. \times 0.36 \times 2.205 = 62.\ S. \text{ dollars.}$$

Interest on cost of conductor, at 10% $= 6.2$ S. dollars.

Sum of cost of power and interest on investment:

$$\frac{64{,}080}{S} + (6.2 \times S.)$$

Solving for S = a minimum: $S = 101.2$ sq. cm. (2)

Total costs, substituting S above

$633 (for power) + $627 (interest) = $1,260 per year.

(3) Power expended in copper conductor

$$\frac{801{,}600}{61.5} = 13{,}035 \text{ watts.}$$

Heat generated in conductor, per second

$$13{,}035 \times 0.2389 = 3{,}114 \text{ gm. cal.}$$

Area of conductor surface

$$(300 \times 100) \times 3.14 \left(\sqrt{61.5} \div 0.7854\right) =$$
$$= 30{,}000 \times 27.8 \text{ (cm. circumference)} = 834{,}000 \text{ sq. cm.}$$

Loss of heat per second by contact with still air, per 1° difference

$$0.000056 \times 834{,}000 = 46.7 \text{ calories.}$$

Rise of temperature, excluding radiation loss

$$3{,}114 \div 46.7 = 67°.$$

The radiation loss must, however, be considered. From copper it is 0.00068 gram calories per second per sq. centimeter, if the surroundings are at 0° and the hot body at 100°, this is approximately 0.0000068 gram calories per each degree in this range. We have the combined conduction and radiation losses per 1° per second

$$0.000056 + 0.000007 = 0.000063 \text{ calories}$$

and the rise in temperature of the conductor

$$3{,}114 \div (0.000063 \times 834{,}000) = 59°.$$

The conductors would therefore run at a temperature of

$$20 + 59 = \mathbf{79°} \text{ C.}$$
$$= 174° \text{ F.} \qquad (3)$$

A correction of the second order would be to take into consideration the fact that at 79° the copper would have less conductivity than at 20°, its resistivity at 79° being

$$0.00000167 \times \frac{273 + 79}{273 + 20} = 0.0000020 \text{ ohm.}$$

This would make the required section for minimum expense 68 sq. cm. instead of 61.5, and would, by increasing the surface, make a different rise in temperature. The power expended would be the equivalent of 3,373 gram calories per second, and the revised temperature of the conductor would be

$$(3{,}373 \div 52.54) + 20 = 64 + 20 = 84° \text{ C.}$$

(4) Power expended in the aluminium conductor

$$\frac{1{,}281{,}600}{101.2} = 12{,}665 \text{ watts.}$$

Heat generated in conductor, per second

$$12{,}665 \times 0.2389 = 3{,}026 \text{ calories.}$$

Area of conductor in square centimeters = 1,074,000 sq. cm.

Conduction and radiation losses, per 1°

$$(0.000056 + 0.000010) \times 1{,}074{,}000 = 70.88 \text{ grm. cal.}$$

Rise in temperature of conductor

$$3{,}026 \div 70.28 = 43°.$$

Working temperature of conductor

$$43 + 20 = \mathbf{63°} \text{ C.} \qquad (4)$$

The aluminium conductor thus is seen to work cooler than the copper, and to admit of a lower minimum of working costs.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Vienna Meeting of the Iron and Steel Institute.

Since abstracts of the papers presented at the Vienna meeting of the Iron and Steel Institute have already been published in the October issue of this journal, the following is simply an account of the proceedings and of the discussions which took place at the meeting.

Owing to the excellent arrangements which had been made by the local executive committee of Vienna the meeting was a full success. The first session was held on the 23d of September, in the building of the Society of Austrian Engineers and Architects. Mr. W. Kestranek, as the chairman of the local committee, extended in English the welcome of his Austrian colleagues to the visiting Institute. He presented to the President of the Institute, Sir Hugh Bell, a gold medal as a remembrance, and referred to the fact that his father, Sir Lowthian Bell, had occupied the chair at the former meeting of the Institute in Vienna twenty-five years ago.

Other speeches of welcome were made by the Austrian Minister of Commerce, Dr. Fort; by the Vice-Mayor of Vienna, Dr. Neumeyer, and by Prof. Klaudy, who spoke for the Society of Austrian Engineers and Architects. Sir Hugh Bell, in his reply in German, expressed the thanks of the Institute.

The first paper was presented by W. Kestranek, on the Austrian Iron Industry (see abstract on page 393 of our October issue). The paper was briefly discussed by Sir Hugh Bell, Mr. W. H. Beckley and Mr. Selby-Bigge. The latter referred to the great progress which has been made in Austria in the use of electric power in the iron and steel mills. The Institute had come to Austria to see the first application of electric power to the driving of rolling mills. Sir Hugh Bell thought that opinions might differ concerning the necessity of protecting the growth of the iron and steel industry behind import duties.

The next papers read were on the Erzberg of Eisenerz, by Prof. H. Bauerman, and on steel and meteoric iron by Prof. Fred. Berwerth. The extended discussion of the latter paper turned chiefly around the magnificent collection of the meteorites in the Imperial Museum of Natural History in Vienna, which is the finest collection of its kind in Europe. Mr. C. Johns had visited the museum and inspected the collection, being interested in the subject as a manufacturer of special steels, and he stated that this inspection of the samples had revealed many novel points to him. In the meteorites he had found structures of which only faint traces are found in commercial steel. The special feature influencing the production of these structures seemed to be that the cooling of the meteorites took place with such an extreme slowness as cannot be approached in the commercial manufacture of steel. Mr. Stead also advised members interested in special steels to study the meteorites carefully. He had been unsuccessful in his attempts to reproduce in the laboratory structures in steel such as found in meteorites.

Prof. J. von Ehrenwerth's paper on the determination of blast-furnace gas (abstracted on page 394 of our October issue) was also discussed at some length. Mr. Greiner, well known through his long activity in this field, objected to some figures in the paper. He had never found 15 per cent of carbonic acid in the gases emitted from blast furnaces working with coke. He found the CO_2 was never more than 9 per cent. The Cockerill Co. based their calculations on Lürmann's tables, which give 5,261 cubic meters per ton of carbon. On the other hand, the author had 2,954 cubic meters per ton of iron, corresponding roughly to 4,600 cubic meters per ton of carbon, while, instead of the 878 calories of the author, he used 925.5 calories.

Prof. von Ehrenwerth, in reply, said that the best results with respect to the utilization of the gases are obtained if the blast furnace does not work to the greatest advantage with respect to the production of pig iron. But for the sake of the latter one has to be satisfied with a low quality of gas. Sir Hugh Bell said that there is a certain discrepancy between the demands of the blast furnace and those of the other sections of the works needing gas power. He trusted that the blast furnace would always carry the victory. It was impossible to have it both ways, and the quantity of fuel per ton of iron was the key to the whole situation. Mr. Greiner remarked that pig iron producers should not be criticised for using more fuel than given by the author in the paper. While the author's figure is 74 kg. per 100 kg. of metal produced, the Cockerill Co. uses 105 kg., and then they have 925.5 calories per cubic meter of gas instead of the author's 878. This is as well as may be wished.

Mr. C. E. Stromeyer's paper on the ageing of mild steel (abstracted on page 395 of our October issue) was the first

paper presented on Oct. 24, and was discussed at length. Sir Hugh Bell remarked that with this paper the author had thrown a bomb into the meeting, and various speakers doubted the results. Mr. Stromeyer did not think that his figures should cause any alarm, and urged steel manufacturers to repeat the test which he has developed.

Mr. B. H. Thwaite's paper on the distribution of electric power from blast furnaces brought out some remarks by Mr. Greiner. A system of the kind suggested by the author has been in practical operation for many years in the Cockerill works. There the cost of the electric kilowatt-year, including everything, amounts to $16.00. Pooling as suggested by the author is an easy thing in Germany with its military education, while the English character would not be equally suited to it.

The balance of the week was spent in various excursions and visits.

THE POSITION OF THE SCOTTISH CYANIDE CO., LTD.

I regret to state that the directors of this company have issued a circular to the shareholders, stating that, as it is practically imposible to produce cyanide with profit at its present low figure, the directors have been compelled to close down the furnaces, and recommend the shareholders to place the company in voluntary liquidation. Unsuccessful efforts have been made to dispose of the works as a going concern. The directors attribute their difficulties to the high price of coal.

MARKET PRICES DURING SEPTEMBER.

Sulphate of ammonia has risen during the month from £11.15 to £12 per ton. Copper sulphate has fallen from £27 to £24 per ton.

As regards copper, the price on September 1 was £75 per ton, irregularities occurred until the 6th, from which date the price fell steadily, until on the 16th the low price of £63.10 per ton was touched, followed by a rise to nearly £67 on the the 17th, remaining nearly steady, until the 20th it commenced to fall again, touching £64 on the 24th, a rise followed to £66.5 on the 26th, the price closing at £64 per ton.

Tin opened at £165.15 per ton, rising to £168 on the 4th, it fell to £166.5 on the 8th, rose to £167.18 on the 9th, at which figure it remained until the 10th, falling again to £159.15 on the 13th, it rose to £169.10 on the 23d, and fell to £160.10 on the 30th.

Lead has shown a steady rise throughout the month, opening at £20 and closing at £21.15.

Cleveland pig iron fell towards the middle of the month, but rose again at the end, the opening price being 56s. 8d., and closing price 55s. 10½d. per ton.

Hematite also shows a fall during the first ten days of the month, opening at 78s. and falling to 75s. 6d. on the 10th, after which it remained very steady, closing at 75s. 4½d. per ton.

The price of antimony is from £43 to £45 per ton.

LONDON, Oct. 7.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Electric Furnaces.

Oxides as Resistors.—B. Saklatwalla (*Zeit. f. Elektrochemie*, Aug. 30) proposes to employ oxides, such as used as filaments in the Nernst lamp, for resistors in electric furnaces. Since they become conductors only at high temperatures they must be preheated. For this reason he has devised a furnace in which the temperature is raised step by step. The lowest range of temperature is obtained by means of nickel; the next range by tin oxide SnO_2, since its resistance decreases very regularly and slowly with temperatures increasing above 600° C.; and the highest range of temperature by means of magnesia, which begins to become a sensible conductor above 1,500° C. The construction of his first experimental furnace is as follows: Compressed stannic oxide powder is finely stamped into the space between two concentric quartz tubes, electric connections being made at both ends by means of platinum rings. A nickel wire is wound around the outer quartz tube and is protected against oxidation by a thick layer of kieselguhr and a fire-clay cylinder. A magnesia tube is inserted into the inner quartz tube, and is connected to the electric circuit by means of two platinum-iridium wires. The following trouble was experienced with this arrangement: Since the tin oxide was enclosed air-tight between the quartz tubes, the tin oxide gases which formed could not escape, and there resulted the formation of hollow spaces within the stamped mass and the current was interrupted. The author intends to make a coherent dense tin oxide cylinder by pressing and burning, so that the quartz tubes are unnecessary.

Electrolytic Production of Caustic and Chlorine.

Diaphragm Cell.—In the laboratory of the University of Geneva extended studies have been carried out in recent years, under the direction of Prof. Guye, on the theory of sodium chloride electrolysis; accounts of this work may be found in *Journal de Chemie Physique*, Vol. I., pp. 121 and 212; Vol. II., p. 79; Vol. IV., p. 222; Vol. V., pp. 528 and 547. A further contribution to the same subject from the same laboratory is published by E. Briner in the same journal, Vol. V., p. 398 (July 31, 1907). The author has investigated the special part played by certain factors, especially the presence of hypochlorous acid. He has determined experimentally, as function of the number of coulombs passed through the diaphragm cell, the quantities of all substances which are present or formed, namely: Cl, HOCl, NaO_3Cl, NaOCl, NaCl, O_2 in the anode compartment, and NaOH, NaOCl, NaO_3Cl and NaCl in the cathode compartment. In confirmation of the theory, the efficiency of chlorine evolution is in the beginning smaller than the efficiency of caustic soda formation (on account of the hypochlorous acid), but with progressing electrolysis the two efficiencies tend to become equal. Finally, the author has confirmed a formula of Guye which permits the determination of the caustic soda formed as function of the coulombs passed.

Fixation of Atmospheric Nitrogen.

Nitric Acid from Air by Means of Discharges.—A useful summary of the numerous patents which have been granted in recent years in different countries in this field is given in a series of articles by H. Danneel in *Zeit. f. Elektrochemie*, March 1, May 3, 10, 17, 24, 31. Theoretically, as high a temperature as possible would be the best one, but in practice it must be taken into consideration that the higher the temperature the greater the cost of producing it and the greater the loss due to dissociation of the formed nitrogen oxide during cooling. It is estimated that 3,500° to 4,000° C. would be the best practical temperature for the formation of nitrogen oxide. The speed of the dissociation of the formed NO is high at the higher temperatures, but becomes negligibly small at about 1,500° C., so that it is necessary to cool the formed NO quickly

down to 1,500° C. Instead of using oxygen and nitrogen in the proportions in which they are contained in atmospheric air, better yields are obtained from mixtures containing oxygen and nitrogen in equal proportions by volume; according to Lovejoy, an addition of hydrogen (less than 10 per cent by volume) is advisable. Ostwald recommends to add argon (10 per cent) or helium to the gas mixture, since the electric discharges then require less voltage. The use of various electric systems for operating the arc is patented by Badische Anilin and Soda Fabrik, among them the use of polyphase currents for producing a deviated arc in rapid rotation. The Salpetersäure Industrie Gesellschaft uses the arrangement

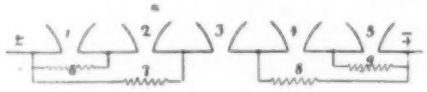


FIG. 1.—METHOD OF CONNECTION OF ARC GAPS.

shown in Fig. 1 for quickly lighting a number of arcs in series without the use of inductance coils, etc.; 1, 2, 3, 4, 5 are five-arc gaps; 6, 7, 8 and 9 high resistances. When the circuit is closed, the whole voltage is impressed on the terminal of gap 3, and the arc 3 is started; then 2 and 4 follow, etc. The resistances 1 to 6 may be made so large that during operation not more than 0.5 per cent of the flame energy is lost in the same. The summary of patents on the production of sparks and arcs given in the article seems to be very complete. It begins with the oldest patents (Mme. Lefebvre, French patent 1 045, April 26, 1859; G. Prim, German patent 20,722, March 15, 1882; Siemens-Halske Co., German patent 85,103, 1894). Numerous diagrams are added. To cool the formed nitrogen oxide quickly, either a blast of air or of steam is used, or in order to prevent the dilution of the gas mixture, the hot gas is cooled by portions of the gas which have already been cooled. The cooling process should have, of course, no effect on the active arc zone. The electrodes are usually made of

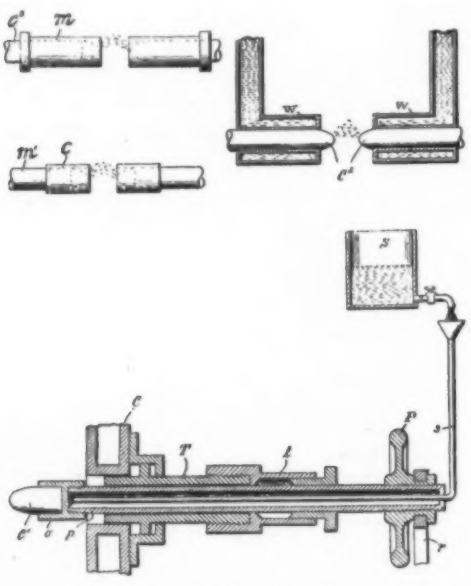


FIG. 2.—CONSTRUCTION OF ELECTRODES.

carbon, which are impregnated with metallic salts or have a core of metallic salt. A strong arc of low resistance is obtained with carbons containing 30 per cent fluorspar. The formation of CO from the carbon diminishes the output, since it reduces the nitrous gases. Fig. 2 shows four constructions of electrodes which are said to have proven satisfactory. The diagram in the upper left-hand corner shows electrodes with a core *c* of a metallic salt, surrounded by a tube *m* of carbon. By bringing the carbons into contact the arc is started. The core of the metallic salt then gets hot and begins to conduct when the carbon tubes *m* are drawn back. In the diagrams right below this the outer tube is made of the metallic salt, and the inner core, which is removable, is of carbon. The other two diagrams show methods of cooling from the outside and inside respectively. Cooling is necessary with metallic electrodes. Numerous patents have been taken out concerning regulating the proportions of nitrate and nitrite formed. Eyde and Birkeland use treatment with ozone to change nitrites into nitrates. The Westdeutsche Thomas Phosphatwerke have a catalytic process of forming ammonia from a mixture of NO and H_2 in contact with platinum black. The process is aided by dark discharges. The temperature must not rise over 80° C. Instead of hydrogen, water-gas or Dawson gas may be used.

In a paper by W. Nuranen and M. Le Blanc in *Zeit. f. Elektrochemie*, June 7, the question is brought up whether the nitric-oxide concentration which is obtained in a vessel with a high-tension arc can be calculated from the nitrogen and oxygen concentration in the gas mixture under treatment according to the law of mass action. "No chemist will deny that the law of mass action is valid for the combustion of nitrogen at a constant temperature. But it is another question whether the mass-action law is also valid for an electric flame, *i. e.*, with an arrangement with a temperature drop." On the basis of experiments this question is answered in the affirmative, and this result is rendered theoretically plausible on the assumption of a monomolecular reaction. This assumption is therefore believed to be correct at the high temperatures in question.

A. Grau and F. Russ give in *Zeit. f. Elektrochemie*, June 21, the results of experiments on the electric-flame arc in various gases: nitrogen, air, oxygen, carbon dioxide, hydrogen, carbon monoxide, sulphur dioxide. For each gas the variations of voltage with current was determined. The same authors give in *Zeit. f. Elektrochemie*, Aug. 23, an account of experiments proving the validity of the law of mass action in the oxidation of atmospheric nitrogen. According to this law, the yield of nitrogen oxide becomes greater if a mixture of nitrogen and oxygen, richer in oxygen than atmospheric air, is used.

Calcium Cyanamide.—A second method of fixation of atmospheric nitrogen is by passing nitrogen over calcium carbide at an elevated temperature whereby calcium cyanamide is formed. Now, it is a peculiar fact that if pure calcium carbide is used the desired reaction with nitrogen will not take place. But commercial calcium carbide contains some calcium oxide, and, according to Frank and Caro, this amount of impurity is sufficient to enable the carbide to combine with the nitrogen at 1,100° C. The nitrogen gas must be free from oxygen, probably because the latter would oxidize the cyanamide with great facility. Neither is producer gas suitable instead of nitrogen, because the CO contained in it would react with the carbide at red heat under formation of burnt lime. The addition of other impurities suggested itself, and it was indeed found that an addition of 10 per cent of $CaCl_2$ has the effect that the combination of the calcium carbide with the nitrogen occurs at a temperature several hundred degrees lower than without the calcium chloride. A temperature of 800° C. is here sufficient. Calcium fluoride acts in a similar way; according to Carlson an addition of 10 per cent of this salt has the effect that the reaction between the carbide and the nitrogen takes place at a temperature of 900° C. Furthermore, according to Carlson, the fluoride is better, because the cyanamide thus produced is not hygroscopic.

The reason why these additions are useful has been the subject of independent investigations by Foerster and Bredig. F. Foerster and H. Jacoby in *Zeit. f. Elektrochemie*, March 22,

show that the addition must remove some obstacle which prevents the progress of the nitrogen absorption. They make it probable that when a lump of carbide reacts on its outer surface with nitrogen this outer surface changes into cyanamide and forms a cover which prevents the nitrogen from reacting with the carbide inside. The addition of calcium chloride (melting point below 800° C.) has probably the effect to liquify or soften this cover, so that the nitrogen can react freely with the carbide below the cover.

G. Bredig, in *Zeit. f. Elektrochemie*, March 1, shows that various other hypotheses which have been proposed to explain the effect of the additions are untenable. In a second paper by G. Bredig, W. Frankel and E. Wilke in *Zeit. f. Elektrochemie*, Sept. 6, they apparently accept the explanation of Foerster, but point out that the melting point of the addition is not the only determining factor. It is necessary to take into consideration the fusion diagram of the total reaction mixture, the solubility of the carbide in the fused bath and the specific total reaction velocity constant in the fused bath. Other things being equal the speed of the absorption of nitrogen is porportional to the pressure of the nitrogen gas within the limits investigated. Of all additions which were tried by these authors the chlorides were found to be the best ones, and among these calcium chloride was most effective.

Argon from Air.—In connection with this matter it is interesting to note a method of F. Fischer, E. B. Maxtet and G. Iliovici in *Zeit. f. Elektrochemie*, March 22, for making argon from air. Calcium carbide containing 10 per cent of calcium chloride is heated in a retort to 800° C., and pure dried atmospheric air are introduced. The oxygen and the nitrogen are absorbed and there remains nothing but argon and the other noble gases.

Action of Electric Spark at Low Temperatures.—An account of experiments by E. Briner and E. Durand is given in *Comptes Rendus*, 1907, Vol. 145, p. 248, and abstracted in the *Journal* of the Society of Chemical Industry, Aug. 31. Electric sparks were passed through dry air at atmospheric pressure at the ordinary temperature, at the temperature of solid carbon dioxide and ether (— 80° C.), and at that of liquid air (— 190° C.), and the amount of nitrogen peroxide formed was estimated from the diminution of pressure. The limiting concentrations reached were respectively 5 to 6, 10 to 15 and 20 per cent, the last corresponding to the complete fixation of the oxygen. Experiments with the vessel immersed in liquid air, and containing in different series mixtures of 4 vols. of nitrogen to 1 of oxygen (air), equal volumes of the two, and 1 vol. of nitrogen to 2 of oxygen, showed that in all cases the ultimate product was nitrogen peroxide. But there is evidence in favor of the view that the spark forms primarily nitric oxide, which is then oxidized in the first place to the trioxide and ultimately, after a longer period, to peroxide. It appears that the fixation of nitrogen as oxide gives better yields than its fixation as ammonia.

Ozone.—An illustrated summary, by Kausch, of recent patents on the production of ozone by electric discharges, is published in *Elektrochem. Zeit.*, June, July and August.

Edison Storage Battery.

Potassium Hydrate.—The transference numbers of the ions of concentrated potassium hydrate, which must be known for an exact calculation of the ionic migration phenomena in the Edison nickel-iron battery, have been determined by G. Nordström (*Zeit. f. Elektrochemie*, Feb. 1). His mean value for the transport number of the cation (K) is $1 - n = 0.224$.

Iron Electrode.—The chemical reactions at the iron electrodes have been studied by O. Faust (*Zeit. f. Elektrochemie*, April 26), who determined complete charge and discharge curves of an iron electrode in a 20 per cent K O H solution against a hydrogen electrode. The discharge curve shows three steps. The "active material" in the first step is hydrogen occluded in the iron during the charging process. In the second step the active material is pure iron, free from hydrogen. In the further discharge the iron must be changed into one of its oxides; it is probable that it changes into Fe_2O_3 or its hydrate.

Nickel Electrode.—A very extended investigation of the Edison battery has been made by F. Foerster, and his results concerning the phenomena at the nickel electrode are given in a paper in *Zeit. f. Elektrochemie*, July 12. When nickelous hydroxide, $Ni(OH)_2$, is charged as anode in potassium hydrate it absorbs more oxygen than corresponds to the formation of Ni_2O_3. As a matter of fact, anodic oxidation of $Ni(OH)_2$ first yields NiO_2, which spontaneously changes later into Ni_2O_3. Accordingly, the charging potential soon rises above the potential of Ni_2O_3. The product of the electrolytic oxidation of $Ni(OH)_2$ is a monophase homogeneous system, presumably a solid solution of NiO_2 in Ni_2O_3. Left alone, it changes spantaneously into Ni_2O_3. with simultaneous change of the potential. A freshly charged nickel electrode has therefore a greater capacity than one which has been at rest for some time after charging, the chief loss of capacity occurring during the first 24 hours after completed charge. When a freshly charged nickel electrode is discharged, the NiO_2 is first reduced, then follows the reduction of Ni_2O_3, and then the reduction of an oxide lower than Ni_2O_3. The reactions during discharge are not the exact reverse of those during charge. The ampere-hour efficiency during charging is almost theoretical for a certain length of time; after the electrode has thus assumed the principal part of its capacity (which is the more the less the current density), the ampere-hour efficiency decreases quickly and rapidly; but in spite of that it is possible to increase the capacity of the electrodes quite considerably still further.

Various Electrochemcal Processes and Experiments.

Electrolysis of Fused Salts.—An important paper by R. Lorenz in *Zeit. f. Elektrochemie*, Aug. 23, refers to the well-known fact that the efficiency of electrolysis of a fused salt of a heavy metal can be very considerably increased by the addition of a salt of an alkali. Such additions have often been recommended and used by practical men in the past, but Lorenz's paper throws an absolutely new light on the rationale of their effectiveness. Lorenz had formerly found that one of the principal phenomena which diminish the efficiency is the formation of a mist or fog or schliere from the fused cathode. Thus in the electrolysis of fused lead chloride with a fused lead cathode, lead goes back into the fused lead chloride bath in form of a mist, which travels over to the anode and there recombines with the anion (in this special case, chlorine), thus undoing the useful work of electrolysis. Lorenz and Helfenstein had formerly found that this migration of the mist toward the anode could be counteracted by separating or enclosing the electrodes by diaphragms, such as perforated glass or porcelain vessels. But he found later that in the case of electrolysis of lead chloride, the simple addition of potassium chloride prevented the mist formation, and was just as effective in increasing the efficiency as the use of a diaphragm. He has now established the fact that this is a general expedient. The efficiency of electrolysis of lead chloride is greatly improved by adding either potassium chloride or sodium chloride or barium chloride; similarly the electrolysis of lead bromide by adding potassium bromide, the electrolysis of cadmium chloride by adding potassium chloride or sodium chloride, etc. In all cases the effect of the addition is to prevent the formation of the cathodic mist. Why the formation of mist is thereby prevented is not yet quite clear, but the following experiment may perhaps indicate the reason. If we have no electrolysis at all, but a fused bath of lead chloride, containing a mist of lead so as to be not transparent, then the simple addition of some potassium chloride suffices to precipitate the mist, and the fused bath becomes transparent. This phenomenon reminds one

directly of the precipitation of colloids by addition of electrolytes.

Artificial Diamonds.—In London *Electrical Engineering* of Sept. 26, we note a French patent, 375,669, granted to L. Bonnet, and relating to a method of obtaining amorphous, fused or black diamond. The process consists in fusing carbon with a high-tension electric current in a liquid or gaseous medium under high pressure. The apparatus consists of a thick vessel of bronze or any other suitable metal, containing two thick carbon electrodes, between which is placed a piece of pure rod carbon. Underneath this rod there is a dish containing carbon disulphide or other liquid which has no action on carbon, and which will readily evaporate and produce a high pressure. A current sufficient to evaporate the carbon disulphide is first passed, and when the pressure is sufficiently high a heavy current, which fuses the carbon, is passed for a few minutes. The pressure may also be produced within the vessel by forcing an indifferent gas into the apparatus by mechanical means. In this connection reference should be had to an account by C. A. Parsons in the September issue of the *Proceedings* of the Royal Society of some recent experiments made by him on the effect of heating carbon electrically to a very high temperature and under strong pressure. The main conclusions to be drawn from his experiments are that at very high temperatures and pressures carbon is still a very good conductor, and that soft crystalline graphite is the resulting stable form of carbon after this treatment. Further, there has never been formed more than a suspicion of black or transparent diamond, and the inference is, therefore, that mechanical pressure is not the cause of the production of diamonds in rapidly cooled iron.

Carbon Crucible.—E. Mueller describes in *Zeit. f. Elektrochemie*, March 22, the simple form of carbon crucible for high-temperature experiments, shown in Fig. 3. The conical carbon crucible is sawed vertically through into two halves and is inserted with its bottom into the closely fitting central hole of a carbon block which is placed on a metal sheet connected to

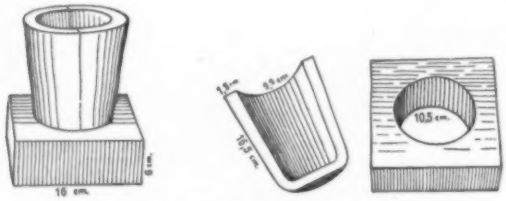


FIG. 3.—CARBON CRUCIBLE.

one pole of the circuit. A carbon rod introduced at the top is connected to the other pole. The advantages of this construction are that it is cheap and permits taking the crucible into parts after the conclusion of the experiment.

Electrolysis of Sulphuric Acid.—In the *Zeit. f. Elektrochemie*, May 31, there is a long paper by E. Mueller and H. Schellhaas on the part which oxysulphuric acid (Caro's reagent) plays in the electrolytic production of persulphuric acid and its salts. For the production of persulphates on a commercial scale it is at present necessary to use a diaphragm cell in order to prevent part of the persulphate formed at the anode from being again reduced at the cathode. For the continuous production of persulphate it is not only necessary that the oxysulphuric acid is destroyed by chemically active additions, but that the persulphate formed is rendered only difficultly soluble. For sodium persulphate production this may be accomplished by the use of concentrated solutions of sodium sulphate containing considerable free sulphuric acid.

Electrolysis of Fused Sodium Nitrate.—A paper by Ch. Couchet and G. Nemirowsky in *Zeit. f. Elektrochemie*, March 29, deals with the electrolysis of fused sodium nitrate under varying conditions. The sodium nitrate is reduced to nitrite at the cathode, while at the anode sodium oxide is formed and various gases are given off. The best yield of nitrite is obtained with graphite electrodes, and the formation of nitrite increases with increasing temperature, with increasing current density and decreasing voltage. The graphite deteriorates the more the higher the temperature and the current density.

Alternating-Current Electrolysis.—Ch. Couchet and W. Chauffat (*Zeit. f. Elektrochemie*, July 12) have studied the electrolysis of sodium nitrate solutions by alternating current. They investigated the effect of current density, concentration, duration of experiment, temperature and frequency. With respect to frequency they obtained in all cases a maximum efficiency at 47 periods.

Electrolytic Rectifier.—J. Sebor and L. Simek in *Zeit. f. Elektrochemie*, March 29, describe some experiments with the aluminium rectifier. The purity of the aluminium appears to be of great influence on the critical voltage. But this influence manifests itself in a different way according to the nature of the electrolyte. If the impurity is present in small quantity only, and shows itself a valve effect like Mg. Sb, the change in the critical voltage is not great.

Electroanalysis.—Evidences of the indefatigable work of Prof. E. F. Smith at the University of Pennsylvania are the following papers, all published in the April issue of the *Journal* of the American Chemical Society: Joel H. Hildebrand, on the determination of anions in the electrolytic way; Anna L. Flanigen, on the electrolytic precipitation of copper from an alkaline cyanide electrolyte; Julia Langness, on electrolytic determination and separation with the use of a rotating anode; L. F. Witmer, on the determining of tin with rotating anode; while the June issue of the *Journal* contains a paper by Lily G. Kollock and E. F. Smith, on the effect of sulphuric acid on the deposition of metals when using a mercury cathode and rotating anode. Of other contributions to electroanalysis the following may be noted: L. T. Sherwood and G. Alleman, in the July issue of the *Journal*, on the use of tin as a cathode for the rapid quantitative electrolytic deposition of zinc, copper, silver, cadmium and nickel, and the following German papers, all of which are published in the *Zeit. f. Elektrochemie:* A. Classen, on several devices for rapid electroanalysis (May 3); F. C. Frary, on a method of stirring the electrolyte for shortening the time of analysis by electromagnetic means similar to Ashcroft's method of stirring a fused lead bath (June 7); A. Fischer, on rapid electroanalysis under observation of the electrode potentials (July 26); N. A. Puschin (April 19), on separation of tin from manganese, iron and chromium; F. Foerster and J. Wolf (May 10), and H. J. S. Sand (June 14), on determination of antimony; A. Fischer (June 28), on determination of nickel from ammonium oxalate solutions.

Physiological Effect of Alternating Current.—Nernst has developed the hypothesis that the physiological effect of the electric current on organic tissues is due to ionic migration, resulting in concentration changes. As soon as the concentration change attains a certain value the first perceptive physiological effect, the irritation of a muscle or a nerve occurs. On the basis of further theoretical considerations, Nernst found a formula according to which the electric irritation of organic tissues by alternating current is proportional to the square root of the frequency, at least as long as the frequency is very low. E. Reiss (*Zeit. f. Elektrochemie*, July 26) has experimentally confirmed this formula for frequencies between 30 and 3,500.

Valency of Silver.—E. Bose (*Zeit. f. Elektrochemie*, July 26) briefly discusses the chemical facts which indicate the existence of silver salts with the valency one-half, and then describes a method of demonstrating experimentally the equilibrium $Ag + Ag^{\cdot} \rightleftarrows Ag_2^{\cdot}$.

Passive State.—In a brief note on the passive state of iron in *Zeit. f. Elektrochemie,* June 7, F. Haber and W. Maitland call attention to several recent observations on the behavior of iron in alkaline solutions, which, in their opinion, can be explained only on the basis of the oxide theory of the passive state of iron. In a note in *Zeit. f. Elektrochemie,* Sept. 6, R. Lohnstein refers to the passive state of magnesium in dilute acetic acid containing some potassium dichromate. Magnesium does not dissolve in this solution except when it is made anode in an electric circuit.

Niobium.—Werner von Bolton, well-known through his work on vanadium and tantalum and the development of the tantalum lamp, has studied the element niobium. He gives his results in *Zeit. f. Elektrochemie,* April 12. He believes to be the first who has produced pure niobium by two methods; one is to produce by the Goldschmidt aluminothermic method an alloy of Nb and Al and to purify this in the flame arc of an electric vacuum furnace until the total aluminium is evaporated. Pure niobium is a half ductile and chemically very noble metal. How difficult it is to produce it pure, appears from the necessity of remelting it about 200 times in vacuo in order to remove all impurities.

Tantalum.—According to M. von Pirani, *Zeit. f. Elektrochemie,* June 21, the specific resistance of pure tantalum is 0.146, with a temperature coefficient of 0.33 for temperatures between 0° and 100° C.

Determining the Melting Point of Metals.—For the determination of the melting point of metals and alloys and for the calibration of thermoelements by fixed points, the molten metal is generally placed in a crucible and by means of a thermoelement, which is protected by a porcelain tube, the temperature is determined. While the fused metal cools and passes into the solid state, the temperature remains constant for some time, and this is the solidification point. This method has the disadvantage that it requires a relatively large quantity of the metal which is molten. For valuable metals, Berthelot has developed another method in which the metal is used in form of a short wire, and this method has been modified by Holborn and Day as follows: The metal wire, the melting point of which is to be determined, is inserted in the thermoelement itself, being connected between the ends of the thermoelement wires. By this method the point is determined at which the needle of the galvanometer returns to the zero point, on account of interruption of the thermocurrent, due to the melting of the wire. But this method has the disadvantage that it cannot be applied to oxidizable metals, the melting point of which depends on the surrounding atmosphere. R. Loebe (*Zeit. f. Elektrochemie,* Aug. 30) recommends to use two separate circuits; one contains the thermoelement, the other the wire whose melting point is to be determined in series with a battery and an electromagnetic device, by means of which a signal is given when the circuit is broken. The wire to be melted and the hot junction of the thermoelement are placed very near together in a closed crucible, which may contain any gas atmosphere or a molten salt, etc. The crucible is heated, and when the signal indicates the melting of the testing wire, the galvanometer is read. L. Holborn (*Zeit. f. Elektrochemie,* Sept. 27) remarks that the method is by no means new, but is useful for oxidizable metals and for such cases in which the optical pyrometer is used for measuring the temperatures.

Determining the Conductivity of an Electrolyte Without Electrodes.—It has long been clearly understood that to measure the conductivity of an electrolyte the influence of the electrodes must be carefully eliminated, since it acts as a disturbing factor. This has mostly been accomplished by using alternating current of sufficiently high frequency. W. S. Franklin and L. A. Freudenberger (*Physical Review,* October) use a method in which no electrodes are used at all. To explain the principle it will be sufficient to describe one of their arrangements. A transformer is so built that it has one primary winding but two secondary circuits, the disposition being exactly symmetrical. One of the secondaries is formed by a ring of glass filled with the electrolyte to be tested. The transformer is essentially a three-core transformer, the two secondaries being placed on the two outer cores and the primary winding is so applied that with the secondaries cut out no flux passes through the middle core. If now the electrolyte is filled into the ring vessel, currents are induced in it by induction, and the balance of the system is destroyed, as is indicated by the fact that a flux now passes through the middle core. Balance is re-established by closing the other secondary on the other outer. The resistance of this second secondary is adjustable. Balance will exist if this resistance equals that of the electrolyte. A method operating on this principle was applied to the test of various salt solutions, and it is interesting to note that within the limits of error the results closely agree with those of Kohlrausch and Holborn.

The Nature of the Over Voltage.—In *Zeit. f. Elektrochemie,* Sept. 20, Felix Kaufler shows that an electrode, while showing the phenomenon of over-voltage (überspannung) becomes heated. At heated platinum electrodes such reactions (reductions or oxidations) which require an over-voltage, may be carried out. With increasing temperature of the electrode and with constant current density the over-voltage decreases. The action of over-voltage in electrolysis may, therefore, be explained essentially by a local heat effect of the electrode, whereby the forming products are rapidly removed from the zone of higher temperature. The hypothesis of an hydrogen or oxygen pressure of several thousand atmospheres at such electrodes becomes therefore superfluous.

Conductivity of Dilute Solutions.—In *Zeit. f. Elektrochemie,* Aug. 30, P. Bogdan tries to show that Ostwald's law for the relation between conductivity and concentration is obeyed by HCl and HNO_3, in solutions which are more dilute than 1/80 normal. But F. Kohlrausch shows in *Zeit. f. Elektrochemie,* Sept. 27, that this conclusion is not justified by Bogdan's figures.

Calcium.—An illustrated summary of the different methods which have been proposed and used for the electrolytic manufacture of metallic calcium is given by Carl Bürgel in *Elektrochem. Zeit.,* January, February, March, April, May. All the methods discussed have been described in our columns. The author thinks the chief problem is now to find commercial applications of calcium.

Tungsten.—According to H. von Wartenberg (*Berichte,* 1907, Vol. 40, p. 3,287) the melting point of pure tungsten is between 2,800° and 2,850° C.

Ionic Mobilities.—In *Zeit. f. Elektrochemie,* March 8, K. Drucker calculates new values of the mobilities of various ions in aqueous solutions on the basis of recent determinations of transport numbers. The results are given in the column marked Drucker, while the older values of Kohlrausch are given below for comparison:

	K.	*Na.*	*Li.*	*Ag.*	*H.*
Drucker	64.4	42.7	32.4	54.0	313.0
Kohlrausch	64.67	43.55	33.44	54.02	318.
		Ca.	*Zn.*	*Cd.*	*Ba.*
Drucker		50.5	41.8	42.3	52.5
Kohlrausch		51.46	46.57	47.35	55.10
		Cl.	*Br.*	NO_3.	SO_{11}.
Drucker		65.2	66.3	62.3	66.7
Kohlrausch		65.44	67.63	61.78	68.14

A critical summary of the whole present situation of ionic mobilities is given by F. Kohlrausch in *Zeit. f. Elektrochemie,* June 21. He gives the following figures for 18° C.:

H.	*Cs.*	*Rb.*	*K.*	*Na.*	*Li.*	*Ag.*	*Tl.*
315	68	67.5	64.6	43.5	33.4	54.3	66.0
I.	*Br.*	*Cl.*	*F.*	*SCN.*	NO_3.	ClO_3.	IO_3.
66.5	67.0	65.5	46.6	56.6	61.7	55.0	33.9

Iron and Steel.

Passivity of Iron.—In connection with the electrochemical theory of the corrosion of iron, which is now attracting so much attention, a paper by Henry L. Heathcote in the *Journal* of the Society of Chemical Industry, Aug. 31, on "the passivifying, passivity and activifying of iron" is interesting. He gives a good summary of what has been done by others in this field and an account of experiments made by himself. The main fact established by him is the intimate connection between the phenomena occuring when liquids are used to passivify or activify iron on the one hand and those manifested when an electric current is employed on the other hand. The conclusion is that the process of passivifying is always electrolytic, and that when no external current is employed we have short-circuited galvanic cells, some parts of the iron surface acting as anodes and others as cathodes. "In accordance with this view, we regard the process of passivifying as occurring in the following manner: When iron is immersed in a solution, some of the metal passes into solution forming ferrous ions, or the ferrous ions in the metal pass into the solution from all parts of the surface. The solution pressure of the iron will not be the same at all parts of the surface, * * * consequently, local electric currents will arise, and if the solution will act as depolarizer at the cathode of the local current, the current may persist until it effects passivification of the iron at the local anode. In this way a number of very small local cathode areas might be associated in the passivification of a much larger local anode area, and the rest of the surface might become passive nearly at the same moment all over. If the solution, however, is not a very vigorous hydrogen depolarizer, or if its action on active iron is vigorous, passivifying may require quite a considerable time." As to the cause of passivity itself, the author considers that all facts are best explained by the theory which postulates a layer of magnetic oxide, Fe_3O_4. "The ions H and OH can be liberated even from aqueous solutions of salts which contain no oxygenated anions, and our results go to show that it is the ion OH which effects passivity, and it is certain that this state is due to the establishment of a solid phase." A useful bibliography on the passive state of iron is added.

Copper.

Copper Silicon.—The nature and composition of the silicides contained in copper-silicon alloys has been studied by M. Philips (*Metallurgie*, Sept. 8 and 22). The alloys were prepared from pure copper and silicon, but before the real investigation was started the following interesting experiment was made: A quantity of fine copper scrap was embedded in a large mass of finely powdered silicon crystals, and covered with a layer of common salt and heated for 5 hours to a temperature of 700° to 750° C. After cooling, the pieces of copper had retained their corners and edges as sharp as before, but had become very brittle, and the fracture showed a uniform silver-white. Analysis gave a content of 9.56 per cent Si. This shows that copper is able to absorb silicon, even below its melting point. The chief result of the author's investigations of silicon-copper alloys—which contain much of interest with respect to analytical refinements and improvements—is the proof of the existence of a copper silicide of the formula Cu_3Si_2.

Gold.

Gold from Gold-Plate Scrap.—The electrolytic recovery of the gold from rolled gold-plate scrap is the subject of an article in the September issue of *The Brass World*. In general, the quantity of gold in rolled plate scrap runs from 1.5 to 18 parts per 1,000. The usual method in smaller plants is to melt the waste in a graphite crucible, shot it by pouring into water and then part the gold and copper by means of a hot, strong sulphuric acid solution. The copper, together with what zinc is present, dissolves as sulphate, while the gold is left in form of a powder. For large plants it is far more economical to melt the waste into anodes and refine them according to electrolytic refining practice. In the article in question some advice is given how to proceed in medium plants. The anodes are best ½ to ¾ inch thick. The electrolyte is a 15 per cent solution of copper sulphate, containing 5 per cent free acid. The electrolyte is kept in circulation by means of a pump. Cathodic current density 5 to 10 amps. per square foot.

Lead.

Electrolytic Refining of Lead.—The process of Anson G. Betts for the electrolytic refining of lead has been described repeatedly and in detail in our columns. An interesting account of the practice in the plant of the Consolidated Mining & Smelting Co., of Canada, Ltd., at Trail, B. C., may be found in a paper by A. G. Wolf in the May issue of the *Western Chemist and Metallurgist*, where also the treatment of slimes and by-products is dealt with.

Nickel.

Rusting of Nickel Plate.—It is a fact of everyday experience that electrolytic nickel plate rusts on any prolonged exposure to moisture, and this rusting is pronounced to be due to small amounts of iron contained in the plate and coming from the solution during the plating process. This impurity may be conceived as constituting with the nickel a series of galvanic couples that cause rapid rusting in the presence of moisture in the air. The iron evidently comes from the impure nickel anodes to which iron is added, since pure nickel anodes would not dissolve to a sufficient degree in the commercial electrolyte of nickel-ammonium sulphate. The way in which the iron passes over from the anode to the cathode has been studied more closely by D. F. Calhane and A. L. Gammage (*Journal*, American Chemical Society, September). Using the ordinary compound anode containing about 7.5 per cent of iron, they found that the amount of iron in the nickel plate will average about 0.10 to 0.14 per cent. If the electrolyte is stirred or the electrodes rotated, the amount of the iron impurity increases very considerably. If the anodes are surrounded by bags or any suitable filtering medium, the amount of the iron impurity is cut down about one-half. Yet iron to the extent of 0.04 to 0.05 per cent will still appear in the nickel plate in spite of filtering septa, and is probably the result of primary deposition by the current. The use of bags over the anodes seems desirable, as they do not appreciably raise the voltage, and they keep the bath much clearer and decrease the iron impurity in the nickel deposit by about one-half. The total avoidance of small amounts of iron in the nickel plate does not seem possible with the anodes at present used in technical work. (It would certainly seem useful to try Dr. Bancroft's suggestion to employ pure nickel anodes and increase their solubility by adding an ammonium chloride or nickel chloride to the nickel-ammonium sulphate electrolyte).

Tin.

Electrometallurgy of Tin.—Another series of articles by H. Mennicke, on the electrometallurgy of tin, has appeared in *Elektrochem. Zeit.*, March, April, May, June, July. He first gives a review of the tin market with its high prices. Concerning detinning, he states that the treatment of tin boxes (instead of tin scrap which was formerly used exclusively) is now increasing in commercial importance; it has been introduced in various plants and the collecting and buying of old tin boxes is being systematized. In view of high prices he thinks that tin refining should pay (see the article by O. Steiner, p. 309 of our August issue). The author then gives a review of patents on the electrometallurgy of tin, granted during the last year, with critical notes. Concerning the detinning of tin boxes, he says that the preparatory treatment is more troublesome than is generally believed. It is first necessary to remove anything that is not tinned iron, such as stones, iron nails, etc. The tin boxes are then rolled so as to decrease

their volume, without compressing them completely. Perforating is said to be unnecessary. Fat, oil, etc., are removed by means of a caustic soda solution; paper, etc., is carburized, and the solder is removed by treatment in a suitable furnace. Finally, after treatment by cutting and rolling machinery, the material is electrolytically detinned.

Ore Dressing.

Electrostatic Separation.—Dr. Friedr. Esser gives in *Metallurgie* Sept. 8 and 22, an account of an investigation made for the Metallurgische Gesellschaft, of Frankfort a. M., and the Maschinenbau Anstalt Humboldt, of Kalk-Cologne, to study the possibilities of electrostatic separation. In the first experiments the electric charges were produced by an electrostatic influence machine, but this was found quite impossible for any continuous operation, because the generation of electricity then depends too much on the humidity in air. The following arrangement was then used. The current from an alternator is fed to a transformer, which raises the voltage, and the high-voltage current is then supplied to a simple commutator, running synchronously with the alternator, so as to get an undirectional high-tension current. As to the construction of the separator reference may be had to the illustration of the Blake separator, our Vol. III., p. 181, although the construction used in the present experiments was somewhat different. Experiments were first made with mixtures of zinc blende and iron pyrites, and it was found that it was necessary to crush the ore at least to ½ mm. size. But even then the separated pyrite was found to contain considerable quantities of zinc. The explanation was found to be that the size of the particles was still too large; in the ore the zinc blende was very intimately united or "impregnated" with the pyrite that some particles of blende of ½ mm. size will carry some pyrite. In this way part of the blende particles become conductors and are carried over with the pyrite. In such cases zinc blende cannot be classed strictly as a non-conductor. Neither is it always correct to class galena as a conductor, since in one experiment of the author galena behaved partly as conductor and partly as a non-conductor, and was carried over in the electrostatic separation in about equal halves to the blende and to the pyrite. As a general result of his experiments the author concludes that electrostatic concentration is applicable with good success only to particles of a size between certain limits. Sizes downwards from 1 mm. to a certain minimum size were found most suitable; above 1 mm. the results were less satisfactory, while the finest powder could not be separated electrostatically. To be successful, it is necessary that each of the particles to be separated consists of the same material; any impregnation with foreign materials acts as a disturbing factor. Zinc blende should not be closely impregnated with pyrite; therefore, those zinc blendes which are poor in iron are most suitable for electrostatic separation. These conclusions, however, are valid only for countries with the same climate as Germany. In districts high above sea level and with a dry climate, as in Chili and Bolivia, the conditions are much more favorable to electrostatic separation.

Miscellaneous.

Electric Power in German Iron and Steel Works.—*Elektr. Kraftbetr. u. Bahnen* of July 24 describes the use of electric power in the Burbacher Hütte, which has two power plants. The older one contains three gas engines, operated by blast-furnace gases driving 240-volt direct-current generators. The newer plant contains a gas engine, operated with coke-oven gas, and a steam turbine; instead of the two-wire 240-volt system of the old plant, the three-wire 2 x 240-volt system is here used. The power is used for driving 300 motors of an aggregate capacity of 3,000 hp., for driving the rolling mills, traction and all kinds of power purposes. For lighting, 4,000 incandescent lamps and 300 arc lamps are used. In the same journal of Aug. 3, G. Meyer describes in great detail the electric charging apparatus for the blast furnaces of the iron and steel works Karlshütte, near Diedenhofen. Detail drawings are given and the Ward-Leonard system is said to have proven very successful in all such installations made by the Siemens-Schuckert Co.

Melting Compounds of the Iron Group Elements.—The *Bulletin of the Bureau of Standards*, Vol. III., No. 3, August, 1907, contains a paper by G. K. Burgess on the determination of melting points of the elements of the iron group by a new radiation method. The chief results are as follows:

Metal.	*Melting Point.*	*Purity.*
Iron	1,505° C.	99.95
Chromium	1,489	98–99
Cobalt	1,464	99.95
Nickel	1,435	99.95
Manganese	1,207	98–99

Of these, the cobalt and nickel melting points appear to be correct to within 5°, while the uncertainty of the iron, chromium and manganese points is probably less than 10° C.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACES.

Boron Carbide.—S. A. Tucker, 869,114, Oct. 22, 1907. Application filed Dec. 19, 1906. Assigned to E. A. Sperry.

The object is the production of pure massive boron carbide B_6C. It has a specific gravity of 2.7, is highly refractory and is an electrical conductor. From it incandescent filaments and high-temperature resistors, arc terminals and electrodes may be made. Boron carbide is also extremely hard, harder than corundum or carborundum. The construction of the furnace is shown in Fig. 1. The mixture of anhydrous boron oxide

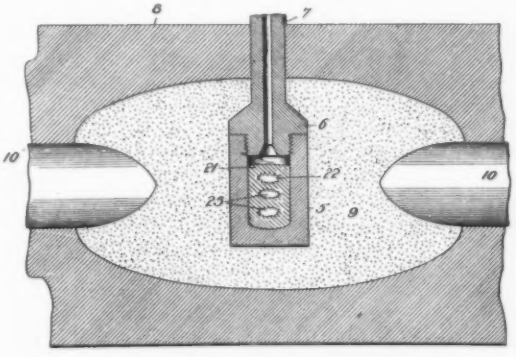


FIG. 1.—BORON CARBIDE FURNACE.

B_2O_3 and carbon in proper proportions is placed within a suitable inclosure, as the chamber 5 made of refractory substance, such, for instance, as pure graphite, and preferably capable of sustaining a pressure without undue leakage, being closed by cap 6, which is supplied with an upwardly extending stem or tube 7. This cell is placed within a cavity in an electric furnace 8, and packed with resistor material, such as carbon or boron carbide particles 9. The terminals 10, 10 lead to the secondary of a transformer. Means are provided whereby the contents of the chamber 5 are brought under suitable pressure. For this purpose the upper end of the tube 7 is provided with a suitable valve. An excess of boron is found advantageous in yielding a purer product. The mixture having been placed in the chamber is heated to a point where the boron oxide melts into a glazy and somewhat viscous mass. At this point in the operation the material has to be stirred. The tem-

perature is then raised to the point where the reaction takes place. The temperature and its distribution is important, and for some purposes it is desirable that the chamber 5 or its equivalent be somewhat elongated and that it be subjected to a non-uniform temperature, so that in this manner upon removal of the product it may be segregated into masses produced at critical temperatures. "In the same compartment, for instance, 21, I have produced crystals as 22, but I find these usually exist in this combination around cavities as 23, opening up in the mass upon cooling. I have made the discovery that crystals, regardless of their exact method of production, are larger with a definite tendency to freedom from fracture and more valuable when the cooling takes place slowly."

Treatment of Ferruginous Zinc Blende.—Woolsey McA. Johnson, 868,345, Oct. 15, 1907. Application filed Jan. 11, 1904.

Ore containing, say, 40 per cent of zinc, 20 per cent of iron, and 30 per cent of sulphur and smaller proportions of copper and lead sulphide and precious metals, is roasted at about 850° to 900° C., whereby the zinc and iron are largely converted into oxides. The roasting need not be complete, and in practice sulphur is not reduced below 3 per cent. This results in the production of a rich gas suitable for conversion into sulphuric acid. The roasted product is mixed with 35 per cent of carbon and subjected to a temperature of 850° to 950° C., whereby the iron oxide is reduced to iron sponge, while the zinc oxide is left unreduced (since it requires for its reduction a temperature of about 1,000° to 1,150° C.). The reduction of the iron oxide to iron sponge may also be effected by means of natural gas. The product of this reduction, containing, in addition to the iron sponge, a zinc oxide, sulphides of zinc, lead and copper and the precious metals with admixed carbon, is then at once subjected to such higher temperatures as are sufficient for the distillation of zinc. This is done in an electric furnace of the resistance type, the iron sponge acting as resistor. The distillation proceeds with great readiness and with but slight consumption of electrical power, because the electric furnace treatment of the charge is begun at a temperature but a few hundred degrees below that required for the reduction of the zinc. The zinc sulphide remaining in the charge is reduced by the iron according to the equation $Fe + ZnS = FeS + Zn$. The iron sulphide formed constitutes the principal constituent of a matte which is found to contain the precious metals of the original ore. The production of iron and zinc in successive steps of the process has the advantages that less electric power is required and that the zinc vapors are less diluted with inert gases, thus facilitating the condensation.

Ferro-Calcium Carbide.—J. Misko, 868,610, Oct. 15, 1907. Application filed Jan. 5, 1907.

Ferro-calcium carbide is made either by adding the proper amount of iron to the charge introduced into the calcium carbide furnace or the iron is added after the calcium carbide has been formed. Concerning its application see the abstract under Recent Metallurgical Patents.

Electrolytic Processes.

Production of Sodium, Etc.—F. von Kuegelgen and G. O. Seward, 868,670, Oct. 22, 1907. Application filed June 13, 1905.

In the production of alkali metals by electrolysis of their fused chlorides it is very important to keep the temperature of the electrolyte so low that there will be no tendency for the metal formed to dissolve in the electrolyte and when reaching the anode to recombine with the chlorine. The difficulty becomes the greater the higher the melting point of the electrolyte. It is, therefore, important to lower the melting point by suitable additions. The inventors propose to accomplish this by the addition of a fluoride, the decomposition voltage of which is higher than the decomposition voltage of the fluoride which is to be decomposed. For instance, in order to produce metallic sodium from fused sodium chloride, the inventors use sodium fluoride and calcium fluoride as the flux, and the mixture of sodium chloride and fluoride is subjected to electrolysis in a suitable vessel, using preferably a carbon anode and an iron cathode and collecting the sodium in such manner that it will not be burned by the air. The proportions may be varied, and they have found that 15 parts of fluoride to 100 parts of NaCl form a very fluid and effective electrolyte.

Magnesium.—G. O. Seward and F. von Kuegelgen, 868,226, Oct. 15, 1907. Application filed Oct. 25, 1905.

The usual electrolyte for the production of magnesium is a fused mixture of magnesium chloride, $MgCl_2$, and an alkali chloride as KCl. The object of the patent is to add such a material which will so increase the specific gravity of the electrolyte that the liberated magnesium metal will float readily on the electrolyte and can be easily collected. For this purpose about 6 per cent of fluorspar is added to the molten mixture of $MgCl_2$ and KCl. This dissolves in the electrolyte. Barium fluoride may be substituted for fluorspar.

Electrolytic Production of Copper.—L. Jumau, 867,046, Sept. 24, 1907. Application filed Dec. 29, 1905.

Roasted copper ore is leached with a solution of ammonia mixed with ammonium sulphate or sulphite. The ammoniacal solution of copper thus obtained may be electrolyzed directly, or the ammonia wherewith the ore was treated may be recovered by evaporation and again used in a subsequent lixiviation of the ore. During the evaporation the copper is precipitated as oxide and may be again dissolved, for instance, in sulphuric acid. The cupric salts contained in the ammoniacal solution are preferably converted into cuprous salts by passing a current of sulphur dioxide (obtained from the roasting furnace) "into the ammoniacal solution, whereby cuprous sulphite or cuprosocupric sulphite or a double sulphite of copper and ammonia is formed." The deposition of copper from cuprous salts requires only one-half the ampere-hours necessary with cupric salt.

Recovery of Nickel.—C. H. Ehrenfeld and J. R. Grove, 868,769, Oct. 22, 1907. Application filed Jan. 27, 1906.

Crushed nickel ore is filled in a porous jar and used as anode, connection to the circuit being made by means of a carbon rod placed in the crushed ore. The jars are placed in the electrolytic tank containing a solution of 10 per cent of sulphuric acid and 10 per cent of acetate of ammonia in water. The nickel is deposited on cathodes outside of the porous jar.

Lead Oxide.—C. P. Townsend, 867,320, Oct. 1, 1907. Application filed April 24, 1905. Assigned to E. A. Sperry.

If a solution of sodium acetate or other alkali metal salt, which is capable of yielding a solvent for lead at the anode by electrolytic decomposition, be electrolyzed between electrodes of lead, a solution of acetate or other salt of lead is formed at the anode, while at the cathode the hydroxide of the alkali metal is produced in equivalent quantity. This alkali metal hydroxide reacts with the lead salt to form a white amorphous precipitate of lead hydroxide, the sodium acetate or equivalent salt employed as an electrolyte being simultaneously regenerated. The special feature of the present invention is that by suitably modifying the above conditions a characteristic crystalline product may be obtained, said product consisting substantially of lead oxide, PbO, instead of the hydrate obtained as above described. A preferred mode of carrying out the process is as follows: An electrolytic cell having an anode of lead and any suitable cathode is sub-divided by a diaphragm of parchment paper, the cathode compartment being advantageously of relatively small capacity. The anolyte consists initially of a solution of sodium acetate of convenient concentration; the initial catholyte may be sodium acetate, water, or preferably a solution of sodium hydroxide. In any case sodium hydroxide accumulates in the cathode compartment until a definite concentration is reached, which is dependent upon the

current strength, the temperature of the electrolyte and other factors, and which remains constant under uniform conditions. Under suitable current conditions brilliant yellow crystals of lead monoxide appear in the anolyte, these crystals or crystalline aggregates having usually the form of thin plates having opposite reëntrant angles. The following working conditions are convenient but may be widely varied: Anodes and cathodes of lead separated by a diaphragm; initial anolyte 10 per cent sodium acetate solution; initial catholyte 2.3 per cent sodium hydroxide solution; temperature of electrolyte 60° C.; current density 20 amps. per square foot electrode surface; potential difference 2.1 volts. When portions of the electrolyte carrying the yellow crystalline product in suspension are withdrawn and the crystals are separated by a filter press or by settling and are dried at about 100° C., the dry product is found to consist substantially of lead and oxygen and to correspond to the formula PbO. The product dried at comparatively low temperatures, as 100° C., possesses peculiar physical properties, especially in that it darkens rapidly under the influence of light, and that the crystalline plates initially formed are subject to rapid disintegration. The product is further characterized by its tendency to hydrate in presence of water, acids or salts, a property which is highly advantageous as rendering it very quickly soluble even in dilute acids; in this respect it is sharply distinguished from ordinary litharge. If the crystalline product be heated to a temperature considerably above 100° C., and preferably to low redness, it is found to differ in several important respects from the product dried at 100° C., and to approach more nearly in properties the monoxide of lead as heretofore known.

Lead Pigment.—E. A. Sperry, 867,435, Oct. 1, 1907. Application filed Aug. 30, 1906.

For the electrolytic production of a lead pigment a previous electrolytic treatment of the lead is stated to be highly advantageous, whereby the lead is used as anode and deposited on the cathode and the cathode product is employed for making the pigment. "For instance, white lead produced electrolytically absorbs as high as 20 mm. (drops) of oil per gram to bring it to a standard paste, whereas by using the cathode product of the first electrolysis as anode in the second, the particle may be rendered harder; it then works entirely different in spreading under the brush, and has other physical characteristics which are different, but probably the most distinguishing feature is that with this lead it is possible to bring oil absorption down to between 3 and 4 mm. per gram. It should be noted in this connection that the after treatments in the two instances are identical with the same electrolyte in the same cell and with the same current density." In the first electrolytic treatment the inventor uses lead tartrate or lead acetate. The cathodic lead obtained thereby is then treated electrolytically to produce the desired pigment. For instance, to make orange mineral the cathode lead from the first electrolysis is washed and used as anode in a second electrolytic cell with sodium acetate as electrolyte. A diaphragm is preferably used to separate the electrodes, the pigment being produced in the anolyte upon the introduction of carbonic acid gas suitably into such anolyte. The white lead thus obtained is of a very superior quality. This is washed free from the electrolyte, and that portion which is to be utilized as orange mineral is then dried and subjected to oxidizing process either in an anodic reaction in electrolytic process or in a furnace at high temperature.

Lithopone.—J. B. and A. Candau, 868,253, Oct. 15, 1907. Application filed April 3, 1905.

Natural barium sulphate is roasted with gold, giving barium sulphide according to the reaction

$$BaSO_4 + 4C = BaS + 4CO.$$

This sulphide is lixiviated according to the ordinary methods. A solution of sodium sulphate is then electrolyzed in a diaphragm cell with zinc anodes and inert cathodes, forming zinc sulphate in the anode compartment and caustic soda in the cathode compartment. The zinc sulphate is precipitated by the barium sulphate which was obtained before, and lithopone is obtained according to the equation

$$ZnSO_4 + BaS = ZnS, BaSO_4.$$

If sodium chloride is used instead of sodium sulphate, zinc chloride is produced in the anode compartment. Lithopone is then obtained from the following complex reaction:

$$BaS + ZnCl_2 = BaCl_2 + ZnS.$$
$$BaCl_2 + Na_2SO_4 = BaSO_4 + 2NaCl.$$

Bleaching of Cotton.—A. A. Vogelsang, 867,452, Oct. 1, 1907. Application filed Sept. 21, 1901.

The method relates to the bleaching of cotton yarn in bulk, that is, without the bundles having to be unpacked, and is also applicable to the bleaching of cops and pirns. The bundles are placed on end in a tank in which they are first treated successively with a caustic solution, with an electrolytic bleaching liquor, and finally with a solution of sulphuric acid. The invention, if applicable to the bleaching of curtains and piece goods, and in the case of curtains a convenient way is to provide a system of rollers so arranged that the articles can be wound backwards and forwards and be caused at the same time to pass through the vats in order to be acted on by the various solutions. The solutions employed may be of the following strengths: "For treating, say, a thousand pounds of cotton yarn, the salt solution may be formed by dissolving 400 kilogs. of salt in 10 cubic meters of water; the sulphuric acid solution by adding 20 pounds of commercial acid (at 66° Baume) to 600 liters, or, say, 2/3 cubic meters of water; while the caustic soda solution consists of 20 to 30 pounds of NaHO dissolved in about 2.5 cubic meters of water, and it is heated to about 50° before it is used."

Electrode.—J. W. Stubbs, 867,319, Oct. 1, 1907. Application filed April 9, 1907.

Carbon blocks form an active surface of the anode, but connection to the external circuit is through metallic rods. Exposed parts of the metallic surfaces are protected by means of a mass composed of a mixture of powdered carbon, resin and tetrachloride of carbon. One possible construction is shown in Fig. 2, where *a* is a metal conductor, covered for the greater part with Portland cement *b*; *c* is a mixture of graphite, resin and tetrachloride of carbon, molded round the end of the conductor, the outer surface *e* of the mass being formed to fit into an opening *f* in the usual carbon block *g*. The end of the conductor is thus efficiently protected from chlorine or other corrosive agents in the electrolyte, and at the same time the electrical resistance of the junction is reduced, while when the block *g* is worn it can readily be removed and a new one put on; *h* is cement for protecting the outer end of the conductor when the opening *f* is made completely through the block *g*.

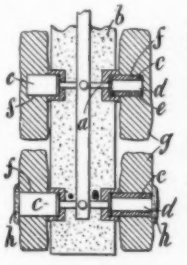


FIG. 2.—ELECTRODE.

Electroplating Apparatus.—L. Potthoff, 866,959, Sept. 24, 1907. Application filed May 1, 1906.

The devices described in this patent are essentially those which were described and illustrated in our August issue, page 331. The first claim reads as follows: "In an electroplating apparatus, the combination with a galvanizing tank and a washing tank, of a single means for moving material through the galvanizing tank to be galvanized and mechanically discharging the material into the washing tank from the galvanizing tank."

Metallic Deposits.—L. Trunkahahn, 868,729, Oct. 22, 1907. Application filed June 4, 1906.

In order to increase the adhesion and the lustre of electro-

lytic metallic deposits, an addition of sugar and a ferment to the electrolyte is recommended. For instance, for depositing zinc the electrolysis is made up by making a mixture of 25 kg. of crystallized sulphate of zinc, 15 kg. of aluminium sulphate, 1 kg. of calcium carbonate, 4 kg. of maltose or dextrose and 0.5 kg. of beer barm.

BATTERIES.

Storage Battery Plates.—H. Leitner, 867,517, Oct. 1, 1907. Application filed Aug. 25, 1904.

The first claim relates to "the process of preparing electrodes for secondary batteries, which consists in immersing the plate in a weak electrolyte, comprising a sulphate solution containing not more than 3½ per cent of the sulphate, to which is added not more than 3½ parts per 1,000 of a chloride, and subjecting the plate as an anode to an electric current of as high density as possible, without raising the temperature of the electrolyte, about 85° F., artificially cooling the electrolyte to permit the use of a higher current density than could otherwise be employed, then washing the plate to cleanse it and consolidate the oxidized layer, then treating the plate as a cathode in an innocuous electrolyte, treating the plate with water and then exposing it to the action of warm air."

Storage Battery Plate.—J. Marx, 867,391, Oct. 1, 1907. Application filed Jan. 30, 1907.

The first claim refers to "a storage battery plate, comprising a frame embodying spaced side bars, bottom and top bars and an intermediate bar, horizontally extending shelves and vertically extending spaced ribs on both sides of said shelves, and units adapted to be held between said shelves and ribs."

DISCHARGES THROUGH GASES.

Sulphuric Acid.—I. Kitsee, 869,094, Oct. 22, 1907. Application filed July 21, 1906.

Sulphuric acid gases are oxidized to sulphuric acid without the aid of a contact mass by simply conveying the gases through ozonized air. The air is ozonized in the usual way by means of electric discharges. If the gases are heated with the addition of some superheated steam the formation of sulphuric acid takes place more rapidly than if the gases are dry.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Iron Reduction with Gaseous Fuel.—The special conditions of California with its scarcity of solid fuel and its abundance of oil are indicated in a process of smelting iron ore patented by Henry Arden, of Los Angeles (869,043 and 869,125, Oct. 22, 1907). A hematite or other iron ore, usually mixed with a suitable flux and with a relatively small proportion of fixed carbon, is charged into the furnace similar in design to an ordinary blast furnace but provided with two sets of tuyeres at different levels, the lower set being located as usual at the level of the crucible and the upper set at approximately one-third the height of the furnace above the crucible. A relatively small proportion of fixed carbon is incorporated with the charge, the amount being sufficient to provide the metal with the 3 or 4 per cent of carbon necessary for its conversion into pig, together with such excess as may be required to effect the reduction of any oxide not reduced by the gaseous fuel. Through the upper tuyeres preheated carbon monoxide is introduced, so as to preheat the ore charge. With the heated carbon monoxide a hydrocarbon, such as a heavy petroleum, previously evaporated and commingled with the gas, is introduced in order to facilitate the absorption of the carbon by the iron. Through the lower tuyeres located at the reducing zone carbon monoxide is introduced preheated to such a high temperature as to effect reduction of the iron oxide. The high temperature is attained by passing the carbon monoxide through an electric furnace adjacent to the smelting furnace, the electric furnace being of the resistance type and provided with heated surface of carbon. In this furnace the carbon monoxide to be introduced through the lower tuyeres is superheated. The gas introduced into the upper tuyeres should be substantially free from carbon dioxide; for this purpose the gas is passed over ignited carbon before being supplied to the upper tuyeres. The carbon monoxide is produced by the production of petroleum or other hydrocarbon in a suitable furnace, the proportion of air being regulated so as to yield carbon monoxide only. The inventor prefers to use an electric resistance furnace for this purpose. In certain cases it is advisable to prevent the carbon from being oxidized during its passage from the upper portion of the furnace to the reducing zone, and this is accomplished by coating the carbon particles with sodium silicate.

Special Steel.—J. Churchward (868,327, Oct. 15, 1907) patents a steel composed of 95.10 per cent of steel (containing 0.6 per cent carbon), 3 per cent nickel, 1.50 chromium, 0.15 vanadium and 0.25 manganese. The percentages may be varied within the following limits

Steel (.20% to 1.25% carbon) from.....	98.30	parts to	91.50	parts.
Nickel from.....	1.00	"	3.50	"
Chromium from.....	.50	"	2.50	"
Manganese from.....	.15	"	1.00	"
Vanadium from.....	.05	"	1.50	"
	100.00	"	100.00	"

"It is believed that the alloying elements named react in a chemical manner on each other, producing molecular changes of such a nature that the nickel, chromium and manganese harden and toughen, and the nickel and vanadium remove or prevent brittleness without softening the alloy."

Calcium for Steel Refining.—J. Misko (868,610, Oct. 15) proposes to refine steel by means of calcium in form of calcium carbide. On account of the high melting point of the latter he uses an alloy of iron and calcium carbide which he calls ferro-calcium-carbide, containing preferably 90 per cent of iron, 6 per cent of calcium and 4 per cent of carbon. To purify iron or steel the alloy is added to the molten metal, The resulting reaction is almost instantaneous. The calcium combines with the sulphur, phosphorus and the gases. It is not necessary in all cases to melt the ferro-calcium-carbide, since it can be thrown into an open-hearth furnace containing molten steel or into a bessemer converter, and also into a cupola furnace where cast iron is being melted.

LEAD.

Joining of Cables, Pipes, Etc.—To join pipes or lead-covered cables, S. L. Smith and T. Harden (868,498, Oct. 15, 1907) patent a flux made as follows: 3 ounces of stearin, 4 ounces of vaseline and 1 tablespoonful of methylated spirit are melted together, and the composition is spread as thinly and evenly as possible upon a sheet of tinfoil weighing 5 ounces per square foot, and another sheet of tinfoil is then pressed down upon the first, making a sandwich which may be rolled, cut into strips, etc. If this sandwich is placed in contact with the surface of a suitable metal and molten lead is poured thereon the lead as it cools will alloy with and adhere to the metal surface. For instance, to join two lead pipes the ends are scraped and put together and the flux is wrapped around the scraped ends and the mold is affixed to the parts to be joined and molten lead poured in.

GOLD AND SILVER.

Cyanide Process.—B. Hall (868,551, Oct. 15, 1907) mixes the crushed ores or concentrates with a cyanide solution to reduce the mass to a loose moist condition. For this purpose the dry material is moistened with from 10 to 20 per cent of cyanide solution, this depending upon the fineness of the material. The mass is then loosened up until it is in such a porous condition that air will circulate through the mass. It is well known that the oxygen of the air is necessary for the reaction. The reaction requires from one to ten days, after which simple leaching with water is required.

MISCELLANEOUS.

Ore-Testing Crucible.—J. E. Hunsinger (868,270, Oct. 15, 1907) patents an ore-testing tablet or crucible for use of the prospector on the spot. The crucible is of such composition as to produce a reducing heat when ignited, and having such fluxes or reagents as the quality of the ore being treated may demand. The tablet is formed of 15 parts of powdered hard-wood charcoal, 8 parts of chlorate of potash and 6 parts of sodium carbonate. This composition is made plastic by paste made of flour and water, and the mass is shaped into round tablets with a plurality of small cells or into crucibles with a large central receptacle. To test the ore, "crush a small amount of ore and grind very fine; then sift through a fine mesh cloth or sieve; place the pulp on top of a tablet or crucible and carefully fill all of the cells and strike off from the top all the remaining pulp; then light the tablet with a match, and when burned and thoroughly cooled place the slag in a suitable mortar and triturate until all of the slag has been washed off. The slag is dissolved at once when water is poured thereon, and any remaining lumps can easily be reduced with the pestle so that every particle of metal may be saved if the operator is careful in panning." For refractory ores where more heat is required two tablets are used, one placed directly on top of the other. A crucible form is shown which is said to be especially suitable for retorting small amounts of amalgam.

Free Engineering Library.

On and after Wednesday, Nov. 6, 1907, the reference libraries of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the American Institute of Mining Engineers, 29 West Thirty-ninth Street, New York, will be open evenings until 9 o'clock on all week days except public holidays. These libraries, constituting practically one library of engineering, situated near the New York Library, in the new headquarters of the United Engineering Societies, are available to members of the above societies, engineers, and the public generally, subject to proper regulations. Strangers are requested to bring letters of introduction from members or to secure cards from the secretaries of the respective societies.

Acid-Proof Brick and Tile.

Acid-proof brick and tile is used extensively for floorings in plating rooms, copper refineries, caustic soda vats, sulphate pulp digesters and in general in all places where perfect non-absorbent, strictly acid-proof floorings or linings are required, and is rapidly claiming the attention of manufacturers in industrial spheres where it was not used before.

The New York Brick & Paving Co., of Syracuse, N. Y., have in the market to-day, and have had for the past fifteen years, a brick which is daily forging ahead in this particular line. These brick are made of alluvial clays, or rather clays of an alluvial deposit, and are a mixture of clays containing very little lime or iron; if any is found in the same the extreme heat in the process of vitrifaction completely destroys them. On this fact is based the great superiority of this brick over ordinary vitrified brick.

These acid-proof brick have been tested by a great many of the best chemists in the United States, and have never failed to prove their excellent quality as acid resisting. No acid has yet been found to affect them, although strongly concentrated solutions have been used on them. The brick are perfectly vitrified, and to accomplish this they are subjected to almost white heat in the process of vitrifaction. Very few clays except this particular one could withstand such a process of vitrifaction.

For the past fifteen years the New York Brick & Paving Co. has been supplying many brass foundries, copper works, as well as sulphite pulp manufacturers with these brick for their various uses, while during the past five years the manufacturers in various metal industries, where hot material is apt to be found on floors, vats, etc., have finally adopted these brick as floorings as being the most durable, since they will outwear any three floors of any other kind of material.

The brick are 2 and 2½ inches thick and 7½ inches long. A double brick or tile is also manufactured by the company of the size 7½ inches x 7½ inches x 2 inches, which is recommended where it is essential to have as few seams as possible. The small size brick answers for any ordinary flooring. The manufacturer, the New York Brick & Paving Co., 204 S. A. & K. Building, Syracuse, N. Y., request correspondence with interested parties and furnish samples upon application.

Concentrating Magnetite Iron Ore at Lyon Mountain, N. Y.

The Delaware & Hudson Co., of Albany, operates extensively in the magnetite mines of Lyon Mountain, N. Y., where for twenty years the crude ore with an average yield of 32 per cent has been mined. In the old mill wet concentration was used, but the new mill, which has only been completed since May, 1906, is arranged for using dry magnetic methods, and the ore is brought to the separator plant without sorting.

The crushing capacity of the new mill is from 1,000 to 1,200 tons of crude ore in 24 hours; 375 hp. is required to run the mill, and ore is crushed to ¼ inch to obtain the best results in separation. Nearly all of the machinery used to equip the new mill was purchased from Allis-Chalmers Co., of Milwaukee.

The mill is divided into three sections, each of which can be separately operated. The crude ore, after weighing, is dumped into a bin of 700 tons capacity, from which it passes over a grizzley of manganese steel bars to a 24-inch x 30-inch Blake crusher and is reduced to about 5 inches. Then the ore passes over a second grizzley to a No. 6 "K" Gates gyratory ore crusher, which reduced it to 2½-inch product. The ore is then delivered to a belt conveyor, which also receives the fine material from the grizzleys and carries the product to a set of 40-inch x 30-inch Allis-Chalmers crushing rolls. These rolls crush the ore to 1 inch in size, and from them it is elevated to the top of a vertical dyrer. After drying, the product is delivered to the bucket elevator and thence to a second storage bin.

Sizing screens are fed from these bins by means of feed rolls, the over-size and the ¾-inch material being delivered to 40-inch x 15-inch crushing rolls of the same type as the coarse rolls. Then the material is passed over revolving screens with ¼-inch apertures. The over-size is returned to the rolls, while the ¼-inch material is elevated to bins over the separator section.

The capacity of each separator is 15 to 20 tons of crude ore. The middlings and tailings from the four primary separations are recrushed on four sets of rolls and again treated on a second set of separators.

The final product, concentrates and tailings, is carried out of the mill on two belt conveyors to the loading pockets. The concentrate pocket has a capacity of about 600 tons. The tailings pass over revolving screens with ⅛-inch apertures, which deliver each product into a bin of 200 tons capacity.

The fine tailings have found good use as locomotive sand, being dry, sharp and clean. The coarse material makes excellent railroad ballast, and is also used for concrete sand.

Excellent results have been obtained here in the separation of magnetite from tailings. Five years ago the tailings from the old mill used to carry 12 to 15 per cent iron. By recrushing and retreating them on the magnetic separator the iron residue has been brought down to 4 per cent in the new mill.

Modern Copper Converters, Hydraulically Operated.

By G. B. Shipley.

A very interesting and modern converter installation is now being made by the Mammoth Copper Company at Kennet, Cal., under the supervision of C. F. Moore, chief engineer. All of the machinery has been designed to meet the most exacting conditions.

The evolution of machinery for converting copper has consisted of a progressive series of improvements, due principally to the many practical experiments made by the various operators at different plants throughout the world, and particularly in the United States. By combining the latest ideas that have yielded the best results, and eliminating defects, it has been possible to build a converter which has many advantages over those used a few years ago.

The converter equipment for the Mammoth Copper Company consists of two hydraulically operated stands and eight shells, 96 inches in diameter by 150 inches long.

Shells.—Referring to the illustration, it will be noted that the shell at the top half has a peculiar shape, which is not found in other converters. The bottom half is 96 inches in diameter, and from the center up to the joint, both sides of the shell are formed in a tangent to a width at the top of about 7 feet. The object of this is to do away with the unnecessary curvature above the center line to permit of a more secure lining being formed.

The parting joint between the bottom half and the top half of the shell is considerably higher than in other designs, the idea being to keep this just as high as possible and away from the extreme action of the molten copper; for it is a fact that in practically all of the barrel converters, with the exception of those at the plants of the Anaconda Copper Mining Company and the Orford Copper Company, this joint is only carried a short distance above the center line; and, since there is here no chance to ram the lining, it is only possible to form the joint with an adobe mixture. The result is that the joint is eaten away very rapidly by the molten matte. In the new type of hydraulically turned converter, built by Allis-Chalmers Company, this vital defect has been overcome by raising the joint between the bottom and top shell.

The bottom section of the shell is made of flange steel plate, which is reinforced longitudinally by four heavy T-rails and rigidly secured at both ends to a solid cast-steel head provided with a riding ring cast integral with and completely encircling the head.

Each head is spherical in shape and reinforced with eight heavy ribs to reduce expansion and contraction resulting from the intense heat. In a great many converters, designed without the ribs, much trouble has been caused and a great deal of expense incurred in fitting relined shells into stands which have the air connections bolted to the heads.

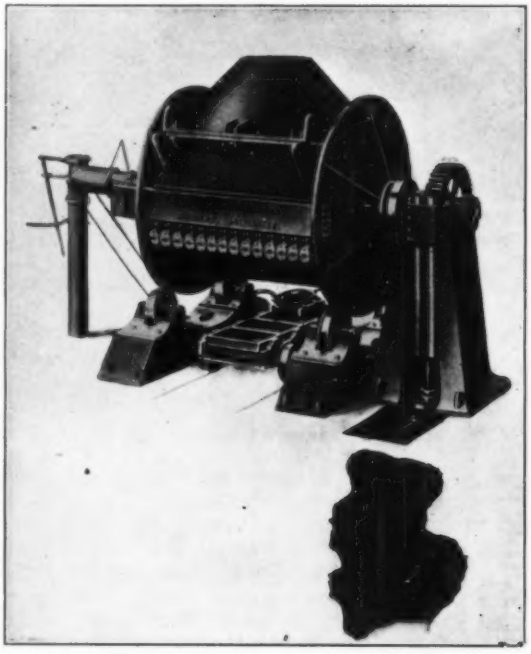
For lifting the shells there is riveted at the joint on the lower half a solid cast-steel re-enforcing plate, which has cast integral with it one heavy lug on each plate, making four lifting lugs in all. These re-enforcing plates or angles are also arranged for bolting on the top half by three extra heavy bolts on each side.

The pouring top is made of cast steel and is parted on the longitudinal center line, thus making this part in two interchangeable sections, which is an important feature when repairs are considered. In some casees a great many operators are in favor of fitting the top with a short cast-iron pouring nose, which can be removed and thrown away when eaten up by the molten metal, and another substituted, whereas there are others who insist that the separate pouring nose is very objectionable, inasmuch as the additional flanges furnish places for accretions to form. With the top as shown in the illustration, it is only necessary to rivet a steel plate at the burnt-out portion. The shape of the top of this converter, as well as the bottom, is practically the same as that of the converters in use at Anaconda, Mont. It is a peculiar shape which gives longer life to the lining.

The wind box is rectangular in shape and consists of a plain casting which lies close to the shell and underneath the riding ring, thus permitting the shells to make a complete revolution and thereby do away with the stop which it has been customary to place on a great many riding rings in order to protect the wind box and prevent the shell from turning too far. With the old stop arrangements it was necessary to be very careful in turning; otherwise an operator might throw the shells off the stands, thus causing a serious accident.

Another feature of the self-contained wind box is that it does away with the long flange and cover which has always been used where the air valves or tuyeres were fitted on the inside of the wind box. It is well known that there is always a great loss of air through the joint in the long cover ordinarily used, because the expansion and contraction and the hard service to which converters are subjected in a very short time ruins the joint.

Individual Tuyeres.—On each of the Mammoth Copper Company's converters there are fitted sixteen Redpath individual tuyeres, having Dyblie ball valves, and secured to the



CONVERTER.

wind box by swing bolts. The discharge end of each valve, which is at right angles to the inlet, projects several inches inside the shell and through a cast-steel stuffing box secured to the shell. This stuffing box is bored out to suit the projection on the tuyere, and is arranged for holding asbestos packing, to prevent air leaks, while the projection inside the shell is sufficient so that a lining of brick can be fitted securely around it.

Each tuyere is arranged so that the ball valve and its seat are self-contained, and the valve can be quickly taken out and replaced by another. The pipe distance-piece is also independent and easily accessible. Therefore, it will be seen that with this individual arrangement of tuyeres, it is only necessary to disconnect two swing bolts and pull out the

tuyere; it is not necessary, when replacing a single defective pipe distance-piece, to disconnect a long and heavy cover and have the great difficulty of trying to make a joint on a long and warped casting.

The opinion of many will probably be that accretions will form between the wind box,, tuyeres, and shell, to such an extent that it will not be possible to get at the swing bolts which fasten the tuyeres to the wind box; but this is not the case, because to obviate this there is an angle on top of the wind box, which runs for the full length and is riveted to the shell.

It has been demonstrated that the ball valve is more satisfactory than the roller or flap valve, because the spherical shape of the ball adjusts itself to the valve seat, leaving no chance for grooves to form as a result of the hard usage and constant pounding of the tuyere punching bar.

Air Connection.—On the air end of each shell, the cast-steel head is arranged to receive the end of the wind box, which is fitted with a ball-joint concave flange, and receives the stationary air nipple of the patented blast connection.

This joint is especially adapted to converters and air joints where it is not possible to bring flanges in line, by reason of the difference in centers of shells, which are bound to become distorted and lose part of their shape after hard usage. This connection consists of a cast-iron T, having the horizontal cylinder fitted with a ball-joint and piston. When the shell is moved into position the lever is pushed forward, and this moves the nipple into the concave flange on the head. The air is then turned on and the pressure upon the piston holds the joint rigidly in place.

This joint is superior to the old method of matching flanges, and has proved to be a great labor-saving device around converter plants.

Hydraulically Operated Stands.—For turning the shell each stand built for the Mammoth Copper Company is provided with a pressure cylinder 18 inches in diameter, having a stroke of 7 feet, which is equivalent to turning shells 180 degrees. The piston is fitted with four special metallic packing rings, which are designed to obviate leakage, wear, and the expensive delays due to repairing soft packing.

The upper end of the cylinder is secured to a flange on the bottom of an A frame and at each end are bolted independent heads. The upper head is fitted with a brass neck bushing and a well-proportioned stuffing box. It will therefore be apparent that with this arrangement it is possible to take the piston and rod out through the top, which is a very desirable feature.

The driving stand is a solid cast-iron box section "A" frame with liberal bearing surface at base, which is arranged for securing to foundation with four 1½-inch bolts.

The upper portion of this driving frame is designed to receive the turning mechanism, which consists of a cast-steel rack and cast-steel shrouded spur-gear. The rack is connected at the lower end of the piston, and opposite to center line of shaft at the upper end a guide is arranged, with a well proportioned sliding surface. Thus it will be seen that the turning motion is transferred from the piston and rack to the gear.

The gear is keyed to a hollow steel shaft which has fitted to its driving end a universal coupling, arranged so that the shells will rest true on the rollers, and that at the same time the drive will adjust itself to suit the alignment, thus avoiding any undue strains on the driving shaft.

On the head of the shell is a groove, which matches a tongue on the universal drive; the main gear is turned around until the tongue is vertical, when the shell is placed and there is clearance enough on each side of the tongue for keys, which are tapped into place by a light hammer, thus holding the shell rigid to the universal connection.

In some converters this groove on the shell has only sufficient clearance to allow the shell to drop over the tongue, and no provision is made for using the keys, in which case there is danger of a back lash, due to the clearance and the fact that the piston will have a chance to accelerate before it picks up the shell, the result being a severe shock which is detrimental to the gears.

Housing.—There is a sheet-steel housing for each frame, which covers the driving gear to prevent dirt from getting into the operating parts.

Pouring Spoon.—A very important detail in connection with the pouring of a converter is to obviate spatter or spilling of the copper upon the floor, and to prevent this there is furnished, when requested, a Bennetts' pouring spoon, hung on a steel arm on one side of the roller stand, as may be seen from the cut, with the arm so arranged that the spoon can be adjusted to suit the pour of copper from the shell and the position of the molds which rest on the truck directly underneath.

Another important detail, which is not shown in the illustration, is a mold car mover, attached to a slide on the inside of the roller stand next to the frame. This mover is operated by an air or hydraulic cylinder, which in turn transmits its power through a piston rod to a guide with an arm that can be dropped into place on a mold car, thus pushing the car along into the proper position to suit the molds.

The following data in relation to these converters will be of interest:

	Tons.
Weight of shell	19
Weight of lining	44
Total	63

Cubic feet of concrete in foundation 1,200.
Capacity of charge 40 per cent. matte.
First charge (new lining) 8.25 tons.
Average charge 10.00 tons.
Maximum charge 14 to 16 tons.
Air-blast pressure 12 to 15 pounds.

Assuming six charges per stand per 24 hours, and twenty-six working days per month, the capacity of each 96-inch by 150-inch converter will be about 1,250,000 pounds of copper per month. Of course this will all depend upon the matte and the conditions under which the converter is operating. In some cases the capacity could be increased 30 per cent. where converting is being done under ideal conditions, whereas in badly arranged plants the above capacity would be high.

C. H. Repath, engineer of the Anaconda Copper Mining Company; F. E. Marcy, of Salt Lake; J. A. Dyblio, and B. H. Bennetts, all deserve special mention for the many features which are incorporated in the hydraulically-operated copper converter described.

Agitating Sulphur Burner.

One of the first uses to which gas analysis was put in the chemical industries was in the manufacture of sulphur dioxide by burning sulphur. It was early recognized that if the supply of air to the sulphur burners was not exactly regulated the operation did not proceed to the best advantage; and for this reason it became general practice to analyze the gases coming from the burners and regulate the air supply to the burners accordingly.

Although this method of regulating the air supply represented a great advance over the old-style sulphur burners, to which air was admitted from the end in unrestricted quantity and ungoverned proportion to the sulphur vapor, yet a perfectly uniform gas could not be obtained, since the conditions in the apparatus fluctuated during operation, and especially since they were not perfectly uniform in all parts of the apparatus.

The fundamental feature of a new agitating sulphur burner,

invented by Mr. J. C. Wise and built by the Raquette Foundry & Supply Co., of Massena, N. Y., as shown in the accompanying illustration, is such a construction that those obnoxious fluctuations are avoided and perfect uniformity of conditions within the combustion chamber of the apparatus is assured.

In the old-style burners the feeding of the oven was the cause of fluctuating conditions. The cold charge smothered for an appreciable period the surface flames upon which it was thrown, thereby lowering the temperature and reducing the capacity. Being fed through the door, the operation allowed an excess of oxygen to rush through the system during the feeding. These troubles are done away with in the Wise sulphur burner by means of the use of automatic hoppers, in which the sulphur is melted by radiated heat and flows in a continuous stream into the bowl of the oven, being at the same temperatures as the contents so that any chilling effect is avoided. The sulphur supply may be regulated to equal the consumption, so that the quantity of sulphur in the bowl remains constant.

With respect to the possibility of maintaining perfectly uniform conditions within the apparatus itself, great emphasis is laid upon the fact that the general form of the pot is circular, and that the draft slots are, therefore, arranged in the form of

SULPHUR BURNER.

a circle and are equidistant from the center of the pot. By this arrangement the several distinct volumes of air passing inward radially through the different slots toward the center of the burner, must travel equal distances, and are, therefore, exposed to like conditions. The tendency is to produce uniformity in the conditions existing throughout the pot and to promote the uniform combustion of the sulphur vapor.

Actual trials have shown that the circular form of the pot increased the general efficiency of the apparatus to an astonishing degree. This is undoubtedly due to the fact that because of the several drafts being produced in different directions but converging towards the center of the pot, a uniform mixture of air and sulphur vapor is produced. Moreover, the combustion chamber is provided with a horizontal baffle-plate or partition with four equal slots at each end. The gas passing from the chamber is therefore split up into ten streams which unite in the upper compartment. This again promotes thorough admixture of air and sulphur vapor.

In some instances it is desirable to admit some air through the dampers or draft slots, located at the ends of different slots in the baffle-plate. The shutters at the ends of the combustion box may be opened to any desired extent, admitting a corresponding amount of air. This auxiliary admission of air is desirable when, for any reason, difficulty is encountered in causing thorough combustion within the oven, and, consequently, there is a tendency for unburned sulphur vapors to pass off in elementary form. Air, when admitted through the ends of the box, as above described, will cause any unburned sulphur vapors to burn and form SO_2, provided the aeriform portions just mentioned have sufficient heat. It should be borne in mind that it may sometimes happen, especially in a rapidly working apparatus, that some portion of sulphur vapor is not brought into contact with a proportionate quantity of air, and while possessing sufficient heat to support combustion, is prevented from being consumed upon this account. In such an instance, the auxiliary air outlets are also useful. The dampers and baffle-plates are essential to thorough combustion.

The first machine of this type was installed in July, 1905, in the Deferiet mill of the St. Regis Paper Co., and has given continually perfect satisfaction. When tested recently no material wear or deterioration could be detected.

During a week's test this machine burned 14,000 pounds of American sulphur in 24 hours, producing a gas testing 18 to 19 per cent SO_2. It occupies only 38½ square feet of floor space, is 10 feet 6 inches high, and weighs approximately 10,000 pounds.

The experience of the Fort Edward mill of the International Paper Co., where two machines of this type were installed in August, 1906, is also interesting. Formerly fifteen flat burners of a total burning area of 460 square feet were employed, in connection with four Partington systems of three tanks each. Each system was equipped with an 18 x 20 duplex vacuum pump. Full capacity was seldom obtained. After the installation of the two new Wise machines the use of the old burners was discontinued and two entire acid systems with the exhausters were cut off. The capacity was greatly increased and an immense saving of sulphur and lime per ton of sulphate pulp was shown. A gas of 18 per cent SO_2 is commonly obtained, and the two machines make about 80 tons sulphite pulp daily.

The very high efficiency obtained is evident from the fact that if the operation was ideal, the sulphur being burnt with atmospheric air of standard composition according to theoretical proportions, the proportion of SO_2 in the gas would be about 21 per cent.

Low Temperature Measurements.

Compared with the enormous progress which has been made in the last years in high-temperature measurements by multifarious methods, comparatively little had been done with respect to low-temperature measurements. For this reason some details of a low-temperature "pyrometer," recently built by the Wilson-Maeulen Co., of New York City, will be found of great interest.

We should, of course, not speak of a "pyrometer" since the instrument is intended to be used in the cold and not in the heat—although the fundamental principle is the same, that of the thermo-couple. There is further some liability of mixing up the usual terms. We speak of the "cold junction" of a thermo-couple and mean the one which is held on a constant temperature, for instance, in melting ice. For a low-temperature instrument, however, this junction really is the warmer junction.

That thermoelectric couples with platinum and its alloys give reliable indications of temperatures above the freezing point of water is of course generally recognized. In endeavoring to extend the sphere of usefulness of the thermo-couple far below

the zero point, the Wilson-Maeulen Co. found that for this special purpose it was preferable not to use platinum, but wires of base metals.

The object was to design an instrument which would give reliable and quick indications of temperature down to about 300° F. In solving the problem the Wilson-Maeulen Co. arranges several couples of base metals in series so that the e. m. f. of the compound thermo-couple is a multiple of the e. m. f. of the single couple.

High internal-resistance galvanometers, as generally found in laboratories and workshops may be used with such compound couples so that it is possible to cover practically the whole temperature scale from the coldest to the highest temperatures obtainable in practice. Practically all galvanometers for thermo-electric work are graduated in millivolts as well as in degrees which correspond with the couples sold with them, and the Wilson-Maeulen Co. supply the base-metal thermo-couples with a temperature chart showing the relation between the millivolt indications on the galvanometer and the actual difference in temperature. It is, therefore, not difficult to use one of these very inexpensive couples, which are of high accuracy for moderate temperature work.

From a test made of six compound thermo-couples at the Bureau of Standards in Washington, the following points are interesting. The couples were tested with immersion of the variable-temperature junction to a depth of about 8 inches in steam, solid carbonic acid and alcohol, and liquid air. The six couples were found to be nearly identical in their behavior. In the steam point the greatest difference in the mean was equivalent to 1.1° F. At the carbonic acid point it was equivalent to 0.3° F., at the liquid air point the agreement was still closer. The observed values were, therefore, averaged, and the couples treated as identical.

An equation of the form $E = at + bt^2 + ct^3$ was computed from these averaged observations and a curve was drawn representing the equation. From this curve the value of the temperature for every millivolt may be found. The results expressed on the Fahrenheit and Centigrade scale are given in the following table, which is applicable when the constant temperature junction is at 32° F. or 0° C.

Millivolts	10.00	6.00	2.00	−2.00	−8.00	−14.00	−20.00	−26.00
Degrees F.	122°	88	51	13	−48	−117	−196	−298
Degrees C.	50°	31.1	10.6	−10.6	−44.4	−82.8	−126.7	−183.3

The accuracy of the values is within 2° F. at the lowest temperatures and somewhat better at the higher temperatures. It is interesting to note that the temperature of −183.3° C. is not more than 90 Centigrade degrees above the theoretical "absolute zero" point of temperature.

The resistance of the couples were measured at room temperature and found to be nearly identical. The values, reduced to the ice point by means of the known temperature coefficients and measurements of the diameters of the copper and constantan wires, were all between 3.58 ohms and 3.60 ohms. The resistance increases with rising temperature, in the vicinity of room temperatures, by about 0.0004 ohm per degree Fahrenheit.

With a voltmeter resistance of 135 ohms and a total resistance of 140 ohms, the differences between the resistances of the couples and their variations of resistance, unless very deeply immersed, will be entirely negligible.

Nickel, Cobalt, Tungsten, Vanadium, Molybdenum, Titanium, Uranium and Tantalum.—A recent publication of the United States Geological Survey, by Frank L. Hess, gives statistical data on the production of these metals in 1906, with interesting notes on their applications in connection with incandescent lamps and special steels. Almost no nickel is produced in this country, and, as usual, much more nickel was imported during 1906 than was consumed, the greater part of the matte produced in Ontario being shipped to this country for refining.

A New Laboratory Electric Furnace and Pyrometer Outfit.

A preliminary model of the new patented quartz-lined electric furnace, designed by Prof. Wm. H. Bristol, was described in the ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, February, 1907, and a few of the possible applications of it for practical work were mentioned. This furnace has now been developed into a suitable form for use with the Wm. H. Bristol recording electric pyrometer (described in the ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, November, 1906), in such a way that the temperature inside the furnace may not only be controlled, but also automatically recorded on a chart. A special laboratory unit consisting of this electric furnace and recording pyrometer with attachments, designed for determining the recalescent points of steel and for hardening small

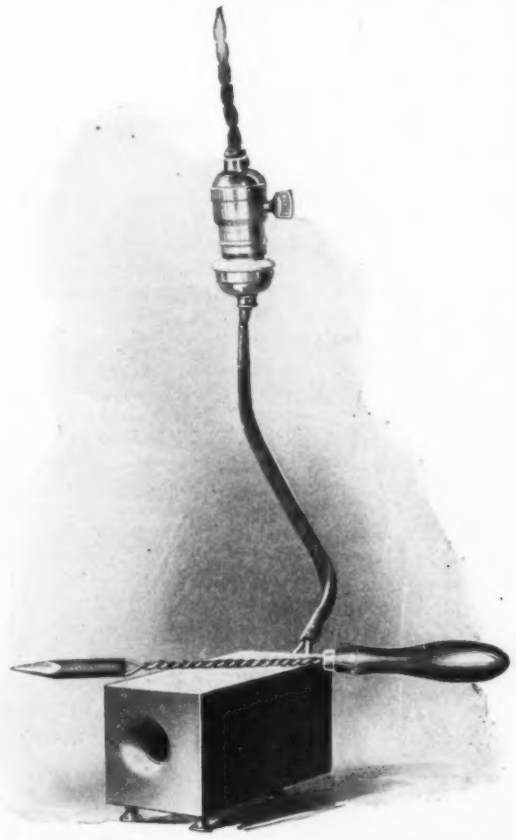


FIG. 1.—QUARTZ-LINED ELECTRIC FURNACE FOR HARDENING SMALL TOOLS.

tools, is shown in Fig. 2, with the various parts all mounted on the same standard in such compact form that the complete unit may even be conveniently used on an office desk, the electric current being supplied from an ordinary lighting circuit.

The electric furnace itself is of very simple construction, its special patented feature being the lining of fused quartz, which makes it possible to turn on the full current suddenly and thus to heat up the furnace quickly without danger of cracking its interior. Even when the furnace is heated to a bright red, a cold piece of steel may be introduced without injury to the quartz lining, which at the same time serves as a perfect insulation between the metal and the heating coils. A rheostat may be used to regulate the temperature, but for some applications this may be dispensed with, as, for instance,

in the use of the furnace as a soldering-iron heater with direct lamp-plug connection. In that case, the winding of the heating coil is so arranged that the maximum temperature of the furnace will be correct for continuous service and not so high as to oxidize the soldering iron. For many other applications as for tools and for laboratory work, both a rheostat and a pyrometer are used with the furnace to great advantage.

Fig. 2 shows the new laboratory unit especially designed for determining the recalescent points of various kinds of steel. The electric furnace is here shown in circuit with a rheostat so that after the full current has been turned on, bringing the furnace up to a bright red heat on the inside almost immediately, the rheostat may be adjusted so as to maintain the desired temperature.

This illustration also shows the complete recording pyrometer mounted on the same standard and consisting of a platinum platinum-rhodium thermocouple and a recorder. The couple of the pyrometer fits into the furnace and has its "cold junction" (or point where the flexible leads begin) inserted into a beaker of ice water. This thermocouple measures the temperature inside the furnace and actuates the recording instrument of the electric pyrometer, the recording arm of which makes a continuous record automatically on its circular chart.

The recording pyrometer is equipped with the patented semi-transparent smoked chart and a special vibrating device which brings the sensitive surface of this chart in contact every half second with the recording arm of a special Weston electrical movement. As friction between the recording arm and the chart is eliminated, a perfectly accurate record is obtained directly without the use of relays or other complicated devices. A chart of special graduations covering a range of 2,000° F., as shown in Fig. 3, is furnished with the outfit. In order that very quick variations of temperature may be recorded, this chart is arranged to revolve once in 60 minutes.

FIG. 3.—RECORDING PYROMETER CHART, SHOWING RECALESCENT POINTS OF STEEL.

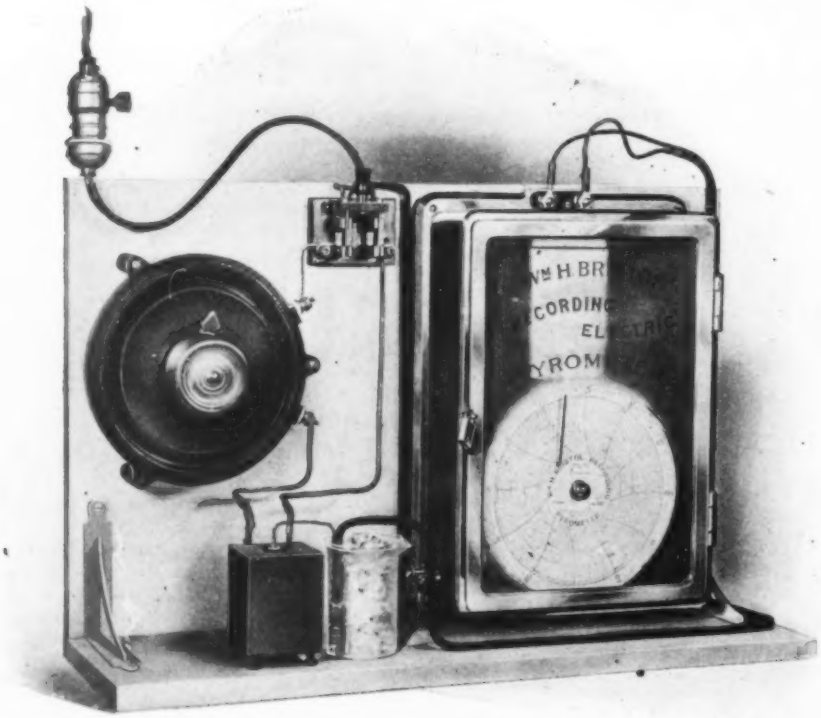


FIG. 2.—ELECTRIC FURNACE AND RECORDING PYROMETER FOR DETERMINING RECALESCENT POINTS OF STEEL.

The special design of this laboratory unit makes it very convenient for measuring the recalescent points of steel, or, in other words, the temperature at which a molecular transformation occurs, below which the steel cannot be hardened. To obtain a record of the recalescent points of a lot of steel, a small sample is selected of cylindrical form about 7/16 inches diameter and about 1¼ inches long. A hole of ⅛ inch diameter and ¾ inch deep is drilled into the end of the sample. After the electric furnace has been heated up by turning on the current, this piece of steel is inserted into the top of the furnace and the tip of the thermocouple is introduced into the hole of the sample. As the steel is gradually heated up by the furnace, the rising temperature inside it will be recorded on the chart. After the temperature has been raised as far as desired, the piece of steel may be withdrawn from the furnace without disturbing the couple, and, as the steel cools, its falling temperature will also be recorded on the chart.

The records of these rising and falling temperatures will be shown as curves on the charts on which the recalescent points will be easily discovered. Fig. 3 shows a chart with four of these records made with four different samples. Sample No. 2 was wrought iron, and its heating and cooling curves show no points where the rise or fall of temperature was retarded. Sample No. 7 was 1.25 per cent carbon steel, and was treated in exactly the same manner as sample No. 2. The record for No. 7 shows two points of retardation, one for heating at

about 1,300° F., and the other one for cooling at about 1,240° F. This shows that to harden this lot of steel, a temperature higher than 1,300° F. should be used. Sample No. 19 was a low carbon steel having different recalescent points. Sample No. 18 was cast iron and shows a point of retardation for cooling only.

It will be observed with reference to Fig. 3 that the complete test of each sample was finished in less than 15 minutes after starting with a cold piece of steel, and that the critical points of the heating and cooling curves were recorded within 7 minutes of each other. It has been found by experience that the curves obtained for these small samples with this outfit have the same characteristics and give the same results as those obtained by using large masses of metal, which would require considerable time for heating and cooling.

From the curves and recalescent points shown in the chart in Fig. 3, it is evident that the temperatures which would be right to harden one kind of steel would not be the right one to produce good results with another kind of steel. By making tests like those described above, the manufacturer can find out what temperature is the best one for him to use in hardening each particular lot of steel. The old-fashioned idea that steel could be hardened by guess-work is fast giving away to the realization that a piece of steel may become either worthless or precious, according to what heat treatment it receives.

The special laboratory outfit described above is being manufactured by Wm. H. Bristol, at 45 Vesey Street, New York City.

Notes.

American Electrochemical Society.—At the meeting of the Board of Directors, held on Sept. 28, in Philadelphia, the following gentlemen were elected members of the Society: Walter G. Clark, president Parker-Clark Electric Co., New York City; Dr. George F. Kunz, gem expert, Tiffany & Co., New York City; Harvey E. Walters, electrician, Pennsylvania Railroad Co., Altoona, Pa., and Frank S. MacGregor, Huff Electrostatic Separator Co., Hyde Park, Mass.

Erratum.—The name of the manufacturers of the various alloys for steel manufacture, described on page 429 of our October issue, is Hermann Essing & Co. In the twelfth line of the note the word sulphur should be substituted for silver.

Manufacture of Vases in Cast Silica.—In a French contemporary we notice a description of a furnace whose inner surface is shaped so as to conform with the exterior surface of the silica article to be manufactured. The furnace is filled with sand, within which is embedded the carbon resistor, which is hollow and has perforated walls so that air may be blown through the holes. When the carbon is raised to red and then white heat, the layer of sand next to the resistor is fused. The excess sand is then taken out, and by continuing the heating the molten sand is completely vitrified. Air blown in through the carbon then blows the vitrified layer outwards and presses it against the side of the furnace, moulding it to the same shape. Objects prepared by this method have a shot color, caused by the innumerable air bubbles enclosed in its mass. These objects, like those made of cast quartz, are capable of standing very great and sudden variations in temperature without cracking.

Modern Welded Pipe.—For the users of a product nothing can be more instructive than a concise outline of the methods by which this product has been manufactured, since these methods determine to a large extent its possibilities or limitations. For this reason a little pamphlet recently issued by the National Tube Co., of Pittsburg, on "The Manufacture of Modern Welded Pipe," should prove very useful, as the description of the progressive operations from ore to finished steel pipe is very clear (although, of course, only general and popular in nature) and profusely illustrated by instructive illustrations. In the process by which 4,000 tons of soft steel ("ingot iron") are made per day by the National Tube Co., the pig iron as tapped from the blast furnace is conveyed in ladles to the 300-ton mixer from which the Bessemer converters are supplied, and the National Tube Co. has succeeded in obtaining unusual uniformity in the composition of their pipe steel; the variation in carbon does not exceed 0.01 per cent from one year's end to the other. This uniformity of product is, of course, of great importance for the welding qualities of the steel, and, further, in reducing the danger of corrosion. The numerous illustrations in the pamphlet are exceedingly pretty.

Colorado College.—Mr. Clyde T. Griswold. E. M., has just entered upon his duties as professor of mining and metallurgy at Colorado College. He succeeds Dr. Thomas T. Read, who accepts the position of professor of metallurgy at the Imperial University in Tientsin, China. Prof. Griswold is a graduate of Amherst College and Columbia University, and was connected for some time with the Canadian Copper Co. Before coming to Colorado College he was superintendent of the Crean Hill Mine, at Victoria Mine, Ontario. He has been connected for some time with this concern, and just before coming to Colorado College was acting as superintendent of construction on their new smelter rearrangements and additions, which were estimated to cost $1,000,000 when completed.

Nitrogen from Air.—According to the London *Electrical Engineering*, Oct. 3, the Government of Bavaria has granted a concession to the Cyanid-Gesellschaft, of Berlin, which is affiliated with the Siemens-Schuckert Co., to utilize the water power of the Alz River at Trostberg. About 15,000 hp. can be obtained from this source. The process to be used is that of Prof. Frank, of the Technische Hochschule at Charlottenburg, in which calcium carbide is converted into calcium cyanamide, the cyanamide being employed as a fertilizer. The same company are already engaged in building a similar works near Bromberg, in the province of Posen, where they are developing 2,000 hp. A project of still greater importance is that of the Badische Anilin und Soda-Fabrik, by which it is intended to extract nitrogen from the air by the Birkeland-Eyde process, using electric discharges. The chief feature of the undertaking is the damming of the Alz River at a point lower than the project above referred to and diverting the water into the Salzach. This will give a large fall and make the power station the largest in Germany. The Mannheim Co. are meeting with considerable difficulties, owing to the peasants asking a very high price for their land. The Bavarian Government are also hesitating whether to grant a charter in view of the plans already mentioned.

Concentration and Briquetting of Iron Ores.—Under this title the American Gröndal-Kjellin Co., of 45 Wall Street, New York City, have just issued a well written and well illustrated pamphlet on the Gröndal processes. We published a paper by Mr. P. McN. Bennie on these interesting processes in our April issue.

Society of Detroit Chemists.—The Society of Detroit Chemists has recently held its first regular meeting, at which Prof. E. D. Campbell, of Ann Arbor, gave an informal talk on "Portland Cement." The Society was formed in the spring of 1907, and has on its list approximately 100 members. With the varied number of industries now located in Detroit it was found when the effort was made to start this Society that an unusually large number of men responded. The Society is an independent organization, whose aims are the furtherance of chemical knowledge, to afford opportunities for the interchange of ideas and for the discussion of all matters bearing upon the science of chemistry.

New Steel Process.—In an article in our September issue, page 344, on the Lash steel process, we stated that the process is to be tested in several industrial electric furnace plants in

Europe, and mentioned among them the Héroult plant in Remscheid. We are informed that the latter note is incorrect, but that a number of electric furnace tests of the Lash process are to be made abroad in the near future.

The Wilson-Maeulen Co. will remove, on Nov. 1, their offices from 110 Liberty Street, New York, to Prince Bay, N. Y. It is the intention of the company in the future to give increased attention in the direction of examination into individual requirements, and they state that they are now in a position to have a practical man call at any works in any part of the country, so that in making installations of pyrometers they can meet existing conditions.

Induction Furnace.—The last volume of the *Transactions* of the American Foundrymen's Association (Philadelphia meeting, 1907) contains an anonymous, but well-written and impartial, article on "the induction furnace for the production of steel by electricity." An elementary description of the fundamental principle of construction and operation is given. It is pointed out that to compensate somewhat for the low power factor it is necessary to use primary current of very low frequency. "This means that special current-generating apparatus will be required, costing from 50 to 75 per cent more than standard generators usually carried in stock by the electrical manufacturing companies. It is also impossible to obtain current for any other type furnace from the central station power plants without using very expensive changing apparatus." The well-known advantages of the induction furnace are then also pointed out. The arrangement of the plant adopted at Gysinge, Sweden, is then described and a comparison is made with the crucible process. It is shown that the induction furnace is perfectly adapted for the production of the finest grades of steel. As to the rapidly increasing demand for large ingots of crucible-steel quality, it is said that "the induction furnace solves this problem, for it is as easy to make a 2-ton charge in such a furnace as a 90-pound charge in a crucible." Figures are given as to cost, showing the great economy of the induction furnace process over the crucible process. Finally, a comparison is made with open-hearth practice. A 736-kw. induction furnace yields 30 tons daily with cold charges and 36 tons with molten charges; 590-kw. hours per ton are consumed in the former case and 490 in the latter case.

Electrolytic Refining in Australia.—With reference to our note on page 248 of our June issue, the following quotation from a recent issue of London *Electrical Review* is interesting, which gives some confirmatory and supplementary information. "At one time it was expected that the Mount Morgan Co. would build its own smelting and refining plant, but instead of doing so it has taken £50,000 interest in the Electrolytic Refining & Smelting Co. of Australia, formed early this year in Sydney, with a capital of £150,000. At present the Mount Morgan Co. sends its blister copper to America for electrolytic treatment and the recovery of the gold, which, of course, takes many months for freightage and treatment before cash is received for shipments; but the new company will not only treat the Mount Morgan blister copper, but probably also that of the Mount Lyell and other Australasian mines. Captain Richard, general manager of the Mount Morgan mine, has been in America visiting many of the largest electrolytic and smelting works in the United States. He has had plans prepared for erecting works at Port Kembla, of which Mr. B. Magnus, manager of the electrolytic refinery of the Calumet and Hecla mine, is to be the manager. Last year Mr. Magnus built the new electrolytic plant of the Mountain Copper Co., near San Francisco. It will be distinctly to the advantage of Australasian copper mining to have a local electrolytic refinery and smelters to which Australian matte can be consigned for treatment instead of having to bear the expense of shipment to the United States and the delay in realization; besides, it will be a great gain, as much of the copper produced can be sold in the Eastern markets, to which it has to be reshipped from America. It is noticeable that the Mount Morgan, while only treating some 7,500 tons of ore per month, has an output of over 400 tons of blister copper. The Mount Lyell, on the other hand, treats about 33,000 tons of ore per month for about 600 tons of blister copper. Then there is the Great Cobar, treating about 14,000 tons of ore per month for about 400 tons of blister copper. This, along with South Australian, Queensland, and other copper mines, should open up a fine field for the new refining and smelting company. The Mount Morgan mine, as a copper producer, is merely in its infancy, as with its 6,000,000 tons of payable copper ore in reserve, it in time will become by far the greatest copper mine in Australasia."

Dr. Hans Goldschmidt's many friends and admirers in this country will be pleased to hear that the distinguished inventor of aluminothermics is again on a visit in this country, in the interest of both the Goldschmidt Thermit Co. and the Goldschmidt Chemical Co.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbide (*Continued.*)

No. 596,999, Jan. 11, 1898, James E. Hewes, of Philadelphia, Pa.

Adds manganese dioxide to the carbide charge, to assist the reaction, prevent escape of volatilized calcium, render fine sub-division and an excess of carbon unnecessary, prevent honeycombing of the product, minimize mechanical losses and increase the output. The preferred charge consists of carbon, 26; calcium oxide, 64; calcium carbonate, 8, and manganese oxide, 2. The flux may be introduced as briquets, pastils or cakes, with or without additional carbon and lime and a carbonaceous binder. The charge may be smelted in an arc furnace 4 feet long, 4 feet wide and 3 feet high, using a direct current of 2,400 amps. at 70 volts. The flux is basic in reaction, and combines with phosphorous and sulphur in the coke to produce phosphides and sulphides, as of calcium, which remain as a slag or crust on the carbide product. When the charge is partially smelted and molten the upper electrode is lowered into the mass and the current then flows without arcing. The product is calcium carbide containing some manganese carbide, which reacts with water to give methane. The mixture of acetylene and methane may be burned without clogging the burner.

No. 601,366, March 29, 1898, C. L. Wilson, C. Muma, J. W. Unger, H. Schneckloth, A. P. Brosius and J. C. Kuchel.

Lime and carbon are mixed and compressed into cylindrical sticks, which are connected end to end by hooks. A number of its connected sticks are placed in a long sleeve or tube of pasteboard, asbestos or metal, and the whole is fed endwise into an arc. Two sets of the inclosed sticks may be fed through hollow electrodes, between whose opposed ends an arc is sprung, or one or two sets, at right-angles to the electrodes, may be fed transversely into the arc. The sticks may be fed horizontally, vertically or at an angle of 45°. The sticks may have transverse openings to enable the heat of the arc to act more rapidly on the mixture. The hooks meet and add an insignificant amount of metal to the carbide product. In a modified apparatus a granular or pulverized mixture of lime and carbon is fed downward through a hollow vertical electrode into an arc sprung to a disc electrode beneath. The bottom and sides of the smelting chamber are covered with pulverized carbide, which receives the molten product and prevents it from adhering to the casing or base.

(*To be Continued.*)

NEW BOOKS.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS.—By R. C. Beardsley, Louis Bell, H. M. Hobart, Otis Allen Kenyon, Edward Lyndon, A. S. McAllister, Kempster B. Miller, William H. Onken, E. F. Roeber, George Shaad. Twenty sections: Units, circuits, instruments, and measurements, materials, magnets, transformers, generators, motors, batteries, central stations, transmission and distribution, illumination, electric traction, electrochemistry, telephony, telegraphy, miscellaneous applications of electricity, wiring, standardization rules, tables and statistics. Bound in flexible morocco; over 1,300 pages, and 1,260 illustrations. Price, $4.00 net, postpaid. New York: McGraw Publishing Co.

ELECTRO-ANALYSIS.—By Edgar F. Smith, professor of the University of Pennsylvania. Fourth edition, revised and enlarged. 336 pages; 42 illustrations. Bound in limp leather. Price, $2.50 net. Philadelphia: P. Blakiston's Son & Co.

TRANSACTIONS OF THE AMERICAN ELECTROCHEMICAL SOCIETY. Vol. XI: Proceedings of the eleventh general meeting, held at Philadelphia, May 2, 3 and 4, 1907. 426 pages; illustrated. Bound in cloth, $3.00 net; to colleges, libraries, technical societies and journals, $2.00 net; to members $2.50 net. South Bethlehem, Pa.: The American Electrochemical Society.

DIE ELEKTROCHEMISCHE UND ELEKTROMETALLURGISCHE INDUSTRIE GROSSBRITANNIENS.—By John B. C. Kershaw, translated into German by Dr. Max Huth. 180 pages; 87 illustrations and 10 tables. In paper cover. Price, marks 9 (retail price in New York $3.00); Halle a S: Wilhelm Knapp.

DIE EISENHÜTTENCHEMIE.—By Max Orthey. 258 pages; 36 illustrations. In paper cover. Price, marks 8 (retail price in New York $2.65); Halle a S: Wilhelm Knapp.

THE CHEMISTRY OF COMMERCE. A simple interpretation of some new chemistry in its relation to modern industry. By Rob Duncan. 277 pages; illustrated. Bound in cloth. Price, $2.00 net. New York: Harper & Bros.

RECENT CYANIDE PRACTICE.—Edited by T. A. Rickard. (With contributions by E. G. Banks, F. L. Bosqui, H. T. Brett, R. Gilman Brown, L. M. N. Bullock, Charles Butters, G. A. Denny, A. E. Drucker, E. M. Hamilton, Francis J. Hobson, Bertram Hunt, Alfred James, H. Julian, A. P. Kennedy, Mark R. Lamb, William Magenau, E. H. Nutter, T. A. Rickard, E. A. H. Tays, Carlos W. Van Law.) Reprinted from articles appearing in the *Mining and Scientific Press* during 1906 and 1907. 350 pages; illustrated. Price, $2.00. San Francisco, Cal.: *Mining and Scientific Press.*

A MANUAL OF FIRE ASSAYING.—By Charles H. Fulton, president of the South Dakota School of Mines. 178 pages; 44 illustrations. Bound in cloth. Price, $2.00, postpaid. New York: Hill Publishing Co.

SIMPLE CHEMICAL EXPERIMENTS.—By T. T. Baker. 72 pages; illustrated. Price, 25 cents. New York: Spon & Chamberlain.

IMMUNOCHEMISTRY.—The application of the principles of physical chemistry to the study of the biological antibodies. By Svante Arrhenius. Being a summary of six lectures on the immunity reactions, delivered at the University of California in 1904. (These lectures illustrate the application of the methods of physical chemistry to the study of the theory of toxins and antoxins. Arrhenius has made a careful analysis of the great work done by the German and French scientists and the totally different deductions they have drawn from their premises. An index of authors and an index of matter makes it possible to use the work to advantage for reference.) 309 pages. Bound in cloth. Price, $1.60 net. New York: The Macmillan Co.

THE CHEMICAL CHARACTER OF THE PROCESS OF FERTILIZATION AND ITS BEARING UPON THE THEORY OF LIFE PHENOMENA.—By Jacques Loeb. 80 pages. Paper cover. Price, 25 cents. Berkeley, Cal.: University of California Press.

HAND BOOK OF TECHNICAL MICROSCOPY.—By T. F. Hanausek. Translated into English by A. L. Winton. Bound in cloth. Price, $5.00. New York: John Wiley & Sons.

ELECTRIC POWER TRANSMISSION. A practical treatise for practical men.—By Dr. Louis Bell. Fifth edition, revised and enlarged. 723 pages; illustrated by tables and diagrams. Bound in cloth. Price, $4.00. New York: McGraw Publishing Co.

ELEMENTARY LESSONS IN HEAT. Fourth edition, revised and enlarged.—By S. E. Tillman. 178 pages; illustrated by tables and diagrams. Bound in cloth. Price, $1.50 net. New York: John Wiley & Sons.

THE FINANCES OF GAS AND ELECTRIC LIGHT AND POWER ENTERPRISES: Electric railways, electric light stations, gas works, oil motor cars.—By W. Dennis Marks. 540 pages; illustrated by tables and diagrams. Bound in cloth. Price, $4.00. New York: William D. Marks.

STUDIES ON THE THERMODYNAMICS OF THE ATMOSPHERE.—By F. H. Bigelow. Paper cover. Price, 25 cents. Washington, D. C.: United States Office of the Superintendent of Documents.

AFTER EARTHQUAKE AND FIRE. A reprint of the articles and editorial comment appearing in the *Mining and Scientific Press* immediately after the disaster at San Francisco, April 18, 1906. 194 pages; illustrated. Bound in cloth. Price, $1.00. San Francisco, Cal.: *Mining and Scientific Press.*

BOOK REVIEWS.

ELECTRO-ANALYSIS. By Edgar F. Smith, Professor of Chemistry at the University of Pennsylvania. Fourth edition, revised and enlarged. 336 pages, with 42 illustrations. Price, $2.50 net. Philadelphia, Pa.: P. Blakiston's Son & Co.

This book by Prof. Smith on electro-analysis is so well known from its former editions that nothing need be said concerning its general scope and character. Every American chemist is proud of Dr. Smith and his work. But much could be said concerning the new features of this fourth edition. The greater portion of the new material included in it refers to the rapid precipitation and separation of metals, the use of a mercury cathode with rotating anode and the employment of a new cell in the determination of cations and anions.

"The section describing the determination of cations and anions cannot fail to excite interest and inquiry. That the estimation, for example, of barium and chloride, in barium chloride, may be made in an hour or less, while hours would be required by time-honored methods, will naturally lead one to pause. The neatness and accuracy of such determinations also recommend them. The determination of the ferro and ferri-cyanogen and other anions indicates still greater possibilities in the application of the current to analysis."

The book is fully up to date. The very latest proposals regarding the value of graded potential in separations and the possibility of effecting organic combustions by means of the electric current receive ample consideration.

What gives the book its particular charm is the fact that the man who describes these fascinating latest developments in electro-analysis is also the man who did the work. When at the last Philadelphia meeting of the American Electrochemical Society, Dr. Smith gave an informal talk on these recent developments, Prof. Chas. F. Chandler said: "Dr. Smith's story is a novel, and is the most interesting chemical

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Uber die Elektrolytische Gewinnung von Brom und Jod. By Dr. Max Schloetter. 50 pages, with 18 illustrations. Price, marks 2.40 (retail price in New York 80 cents). Halle a. S.: Wilhelm Knapp. (Volume XXVII. of German Monographs on Applied Electrochemistry.)

This monograph is a concise summary of the different processes which have been proposed or introduced into practice for the electrolytic production of bromine and iodine, most of the descriptions being based on patent specifications. To those interested in manufacture of bromine and iodine the book should prove useful.

Thirty-seven pages of the book refer to bromine, 13 pages to iodine. As to bromine, the chemical methods of Frank and the process of the Leopoldshall Co.'s are first briefly described, as well as the later Neustassfurt process, in which liquid chlorine is used. Of electrolytic methods those of Wünsche (Westereglen), Höpfner, Nahnsen, Kossuth, Mehns and Pemsel are described, and a few words (fourteen lines together) are said concerning the process of the Dow Chemical Co. and a process of A. G. Betts. As to iodine, the electrolytic processes of Parker & Robinson and of Engelhardt are described. Notes are added on the purification and analysis and on the properties and uses of bromine and iodine.

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Electrochemistry of Organic Compounds. By Dr. Walter Löb. Authorized translation by H. W. F. Lorenz, A. M., Ph. D. 308 pages; 10 figures. Price, bound in cloth, $3.00. New York: John Wiley & Sons.

Although this second English edition from the third German was issued some time ago, it deserves, even at this belated date, special mention, as representing characteristically the surprising progress of electrochemistry in only one branch of chemical science. The previous edition has been entirely rewritten and rearranged, a new chapter has been added on the theoretics of organic chemistry, another on methods, another on electric endosmose, and a whole new section of fifty-three pages has been added upon electrothermic processes and the silent discharge, comprising chapters on the spark discharge and the voltaic arc, the utilization of current heat in solid conductors, and the chemical effects of the silent discharge and of Tesla currents.

The translation is skillfully done, the typography of the book is attractice; and, altogether, English-speaking electrochemists and organic chemists are to be congratulated on having so excellent a work at their disposal.

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Department of Commerce and Labor, Bureau of the Census. S. N. D. North, Director. Bulletins 81 to 88. Washington, D. C.: Government Printing Office.

All these bulletins which have just been issued are parts of the Census of Manufactures for 1905. Bulletin 81 refers to shipbuilding; 82 to musical instruments, attachments and ma-

terials; 83 to slaughtering and meat packing, manufactured ice and salt; 84 to carriages and wagons and the steam and street railroad car industry; 85 to pens and pencils, buttons, needles, pins and hooks and eyes, oilcloth and linoleum, and turpentine and rosin; 86 to copper, lead and zinc smelting and refining; 87 to tobacco; 88 to power employed in manufactures.

From bulletin 86, prepared by Story B. Ladd, we gather the following interesting data. In all the different copper, lead and zinc smelting refining plants the value of the products in 1900 and in 1905 was as follows:

	1900.	1905.
Copper	$165,131,670	$240,780,216
Lead	175,466,304	185,826,839
Zinc	18,188,498	24,791,299

It will be seen that the increase in copper was 45.8 per cent, in lead 5.9 per cent, in zinc 36.3 per cent, and that the relative position of copper and lead has been reversed between 1900 and 1905. This is also shown by the facts that the increase in capital in both the copper and zinc industries has been large in the same period, whereas in the lead industry there is shown a decrease. The same holds true of the average number of wage-earners employed.

It is to be considered, however, that the statistics of the copper and lead smelting industries are colored by the practice of smelting dry ores of the precious metals along with base ores, and a large increase in the consumption of dry ores by copper smelters at the expense of the lead smelters has helped to swell the growth of the copper smelting and refining industry. This is a point on which we commented in an editorial note in November, 1905 (our Vol. III., p. 407). It is brought out in an instructive way in the following figures, which give the gold and silver production of the copper smelting and refining and lead smelting and refining industries for 1900 and 1905. The figures are also given for the copper product of the former industry, exclusive of Lake copper, and the lead product of the latter industry, exclusive of soft lead—which exclusions are made for the reason that dry ores, so called, are not smelted in conjunction with Lake copper ores or "mineral" or soft lead ores:

Copper Smelting and Refining.

	1900.	1905.
Silver, ounces fine	13,229 911	28,115,790
Gold, ounces fine	224,352	636,207
Copper, not including Lake copper, pounds	444,654,289	728,620,488

Lead Smelting and Refining.

	1900.	1905.
Silver, ounces fine	70,420,917	71,920,997
Gold, ounces fine	2,514,836	2,543,757
Lead, not including soft lead, pounds	497,455,931	613,331,956

It will be seen that the increase in the gold and silver products of the copper industry was very large (increase in silver 113 per cent, gold 184 per cent) and greatly in excess of the increase in the related copper product (63.9 per cent), whereas the gains in the gold and silver products in the lead smelting and refining industry are very small and fall far below that for the related lead product. As we have pointed out before, the increase in the consumption of dry ores by copper smelters appears to be due in part to the development of electrolytic copper refining, whereby gold and silver values are easily and cheaply recovered, and also due to the fact that, in the rapid advance in the art of matte smelting, copper has proved to be on the whole a better absorbent of the precious metals than lead.

The number of copper smelting and refining works has decreased from 47 in 1900 to 40 in 1905, the capital invested has increased from $53,063,395 to $76,824,640, and the value of products from $165,131,670 to $240,780,216.

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The number of lead smelting and refining works has decreased from 39 in 1900 to 32 in 1905, the capital invested from $72,148,933 to $63,822,810, while the value of the products has increased in the same period from $175,466,304 to $185,826,839.

The zinc industry has passed through a continuous and healthy growth during the last quarter of a century. The production of spelter, including sheet zinc, was 23,239 tons in 1880, 58,860 in 1890, 131,546 in 1900, and 186,990 in 1905.

In 1900, although the quantity of zinc made by the Western establishments exceeded the zinc output of the Eastern plants, the total value of the products of the Eastern plants was largely in excess, the latter producing $3,143,370 of zinc oxide and sulphuric acid, besides other products, in addition to spelter and sheet zinc products. In 1900 the output of the Western smelters was all in the form of spelter, while of the Eastern establishments only 67.8 per cent of the total products was spelter and sheet zinc.

In the five years after 1900 the situation has been changed, as follows: For 1905 the Western establishments show a production of 257,632,103 pounds of zinc (spelter and sheet zinc), of a value of $12,823,354, an increase of 77.4 per cent in quantity and 64.4 per cent in value over 1900, and in addition zinc oxide, sulphuric acid and other products of a value of $1,234,269. On the other hand, the Eastern works show a slight decrease in zinc metal production for 1905 compared with 1900, but an increase in other products, the total products of the Eastern smelters showing a small increase of 3.3 per cent, as compared with an increase of 80.2 per cent for the Western works. For 1905, zinc metal constituted 59.5 per cent of the total products of the Eastern works (against 67.8 per cent in 1900) and 91.2 per cent (against 100) of the product of the Western.

We have taken from the report only the most general figures and those which show general tendencies in the development of the metallurgical industry of this country. Concerning detailed figures, especially statistics arranged according to States and Territories, the reader must be referred to the original bulletin. Many of our readers will also find much of interest in bulletins 83 and 89, containing, respectively, reports by Prof. Charles E. Munroe on the manufacture of salt, and by Mr. T. C. Martin on power employed in manufactures.

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TRANSACTIONS OF THE AMERICAN ELECTROCHEMICAL SOCIETY. Volume XI. 426 pages; illustrated. Price, $3.00 net. To colleges, libraries, technical societies and journals, $2.00 net. South Bethlehem, Pa.: The American Electrochemical Society.

This is one of the largest volumes so far issued by the American Electrochemical Society. It covers the proceedings of the meeting held in Philadelphia in May, 1907, and contains thirty papers. Since full abstracts of all which were read at the meeting were given in our June issue, we will mention here only those which were read by title and now appear in the *Transactions* for the first time in print. These are a well-written biographical sketch of Moissan, from the pen of G. F. Kunz, and an interesting and suggestive discussion, by W. McA. Johnson, of the electrometallurgy of zinc and its relation to present practice. The latter paper covers about the same ground, though in greater detail, as the same author's article in our March issue (page 83 of our present volume).

In re-reading Mr. Carl Hering's presidential address, we are reminded of the fact that there once was a scheme which, in its consequences, would have changed the Society practically into the electrochemical section of the American Chemical Society. From the fact that nothing whatever has been heard of it again we may conclude that the scheme has died a well deserved natural death. Certainly the success of the Philadelphia meeting and of the recent New York meeting indicate that the American Electrochemical Society is strong enough to do excellent work as an independent organization. President C. F. Burgess' picture appears as frontispiece.

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